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Pesticides Abstracts and News Summary

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SECTION A

INSECTICIDES

Vol. 3 No. 1 February 1957

COLONIAL PESTICIDES RESEARCH COMMITTEE
COLONIAL OFFICE, LONDON

The abstracts contained in P.A.N.S. are in general abstracts of interim reports. The conclusions stated are, therefore, tentative and may be modified by the results of subsequent investigations.

Permission to quote from these abstracts or the original papers must be obtained from the authors.

Enquiries should be addressed to : Colonial Pesticides Information Service, Imperial Institute, South Kensington, London, S.W.7.

EDITORIAL

As this journal embarks upon the third year of its production under the auspices of the Colonial Office, it is encouraging to have to record the increasing demand for it both from within and without the Service. This confirms us in the belief that it is fulfilling a valuable function.

There has been a good response to our circulated appeal for corrections to our address list, and this issue is to be distributed according to the latest revision. There should, in future, be fewer issues going astray in the post. Quite apart, however, from an annual circular, we are always glad to receive revisions or corrections of addresses, and would be grateful if any recipients whose addresses are wrong or obsolete will tell us.

The past year 1956 has been notable in Pesticide Research for the appearance of the highest degree of insecticide resistance so far recorded in a mosquito - or, indeed, perhaps in any normally susceptible insect. Even more startling is the fact that that resistance is against Dieldrin, hitherto regarded as one of the most potent of the residual insecticides. The genetics of the resistance has been worked out (and preliminary reports published in "Nature") at the London School of Hygiene and Tropical Medicine, and it appears that in this case a single major gene is responsible. Three abstracts of field reports on the occurrence of the resistance are given in the present issue.

The World Health Organization too has shown its appreciation of the danger faced by its worldwide malaria eradication campaigns as a result of the appearance of insecticide tolerance or resistance by mosquitoes. In particular, Dr. A. W. A. Brown, formerly of London, Ontario, has now joined them at Geneva in order to co-ordinate studies of resistance and already various laboratories throughout the world are being induced to study resistance more closely. It is hoped that these studies will lead to considerable alleviation of the problem.

We are grateful, as always, to various individuals and bodies who have kept us supplied with up-to-date information and reports for abstraction, and hope that as time goes on, more and more people who have something to tell us, will do so.

A happy New Year to all.

(i) ORGANO TIN COMPOUNDS FOR TIMBER

Tributyl tin acetate is reported by Britton in the Quarterly Journal (No. 36) of the Tin Research Institute to have given sufficiently good results in preliminary tests as a timber preservative to warrant more extended trials.

Test panels (18 x 6 x 0.75 in.) of Common Elm, Wych Elm, Beech and Corsican Pine Sapwood, were immersed in Shoreham Harbour for 18 months; some of each were untreated whilst others were impregnated with creosote, tributyl tin hydroxide (0.5% aq. solution) or tributyl tin acetate (0.5% in diacetone alcohol).

It was found that tributyl tin acetate and creosote completely prevented teredo attack and kept gribble attack to trifling amounts in the more easily impregnated woods. The hydroxide had a lesser but significant action on the borers. For the less easily impregnated Wych Elm, tributyl tin acetate was more effective than creosote.

(ii) MALATHION FORMULATIONS

Standardised Disinfectants Co. Ltd. is marketing, under the trade mark 'Malastan', a useful range of formulations based on malathion, including 40% emulsion concentrate, 20% liquid concentrate, 3% Fog solution (based on a high flash point suitable for thermal fogging) and a combination of malathion and lindane (to prolong the residual activity of malathion).

Reference to these and to the chemical, physical, toxicological properties of malathion is contained in a brochure issued by the manufacturer. The usefulness of malathion formulations in fly (especially resistant varieties) and mosquito control and other public health applications is noted.

Recommendations are also given for spraying against a number of agricultural and horticultural pests including several species of aphids, mites, leaf hoppers etc.

(iii) PHOSDRIN (OS 2046): A NEW SYSTEMIC INSECTICIDE

An organo-phosphorus compound, introduced by Shell as Phosdrin (OS 2046) is stated to be highly toxic to a large number of insects and mites. The compound is 2-carbomethoxy-1-methylvinyl dimethyl phosphate., which is a liquid possessing a high boiling point (106-107.5°C at 1 mm) and a density of 1.24. It is miscible with water and common organic solvents, such as xylene and acetone, but is less than 5% soluble in deodorised kerosene.

Among other properties listed are its volatility (50% lost from filter paper in 4 days) and water stability (half-life greater than 7 days.

The compound is characterised by systemic activity of short duration when applied as a spray. The spray can be prepared by diluting the technical material with water. Improvement in wetting, if required, is obtained by separately adding an emulsifier. This treatment may be found suitable against pests not readily accessible through contact insecticides such as cabbage aphids on broccoli.

Phosdrin (OS 2046) is a strong anticholinesterase poison with a mammalian toxicity of the same order of magnitude as parathion. Its acute oral LD_{50} to rats and mice is rated at 13 and 9 mg/kg respectively. It has an ID_{50} (human blood cell cholinesterase inhibition) of 2.3×10^{-6} molar. The usual precautions must therefore be observed when handling cholinesterase inhibiting insecticides.

The results of small scale field trials carried out in California are quoted below.

Crop	Pest	Dosage	% Mortality at Days after Treatment
Alfalfa	Pea aphid	0.25 lb/10 gal/acre	1 day 93%, 7 days 99%
Artichoke	Aphid	0.25 lb/100 gal to run off	3 days 100%
Lima beans	Two-spotted spider mite	0.25 lb/15 gal/acre	1 day 99%
Broccoli	Cabbage aphid	0.125 lb/8 gal/acre	2 day 75%, 10 day 70%
		0.25 lb/8 gal/acre	2 day 85%, 10 day 95%
		0.5 lb/8 gal/acre	2 day 95%, 10 day 95%
Onions	Onion thrips	0.25 lb/8 gal/acre	1 day 85%
Peas	Pea aphid	0.25 lb/10 gal/acre	1 day 100%
Peas	Onion thrips	0.25 lb/10 gal/acre	1 day 97%

(iv) TRITISAN W

A new non-mercurial dual purpose wheat seed dressing, particularly intended for use on poor quality seed wheats of high moisture content (16% or above) is being marketed by Bayer Agriculture Ltd.

Named Tritisan W, the preparation contains the fungicides hexachlorobenzene (HCB), thiram (TMT) and the insecticide aldrin. HCB is intended for the control of bunt; TMT is primarily for the control of foot rots such as Fusarium, but also to prevent moulds on damp, stored grain and for partial bunt control. Aldrin is included for controlling wire-worm for which it is considered suitable on low vigour seed.

Tritisan W is claimed to be as efficient fungicidally as standard organo-mercurial dressings, without the phytotoxic risk.

(v) ORTHOCIDE PEA SEED DRESSING

Murphy Chemical Co. Ltd. have introduced a pea seed dressing containing 75% captan designed to prevent pre-emergence "Damping Off" and "Foot Rots" which attack seeds and seedlings. The dressing is recommended for use on peas, beans and sweet corn at 2½ oz. per 1 cwt. seed or at double this rate for brassicas, marrows, cucumbers and spinach. It is claimed to be more pleasant to handle than thiram dressings and of being more easily applied because of its effectiveness at a lower rate.

(vi) THE MEDITERRANEAN FRUIT FLY ORDER, 1956

Determination to stamp out Mediterranean fruit fly from Cyprus in evinced by the recent citation of the Governor. This Order may be cited as the Mediterranean Fruit Fly Order, 1956.

Mediterranean fruit fly (Ceratitis capitata Weid.) causes damage to several kinds of fruit on the island according to the season. Citrus fruits are particularly susceptible but others including apricots, peaches and pears may be severely attacked. Damage is caused when the female fly punctures the skin of the fruit to deposit up to 10 eggs. It is most marked in February or March when the eggs rapidly hatch out to release maggots which proceed to burrow deep into the fruit. During the latter part of the year the fruit is unlikely to become so severely infested, but there is a tendency for fruit attacked at this time to drop prematurely.

A pressing demand for cleaner, high grade fruit, along with the effective measures of control, in the shape of dieldrin, that are now available, have contributed to the force of this legislation.

The form and timing of the treatment are embodied in this Order as follows:-

> "Within any district, area or place declared by the Governor to be infested by the insect known as Ceratitis capitata Weid., the Mediterranean fruit fly, the following provisions shall have effect:
>
> All fruit-bearing tangerine, oval orange, and sweet orange trees within the said district, area, or place, shall be sprayed at least once a year with the insecticide known as dieldrin. The rate of application of the insecticide dieldrin shall be as follows:
>
> For trees 4 to 8 years old, minimum ½ oke of 25% dieldrin per donum. (1 oke = 2.8 lbs; 1 donum = 1600 sq. yds.)
> For trees 9 to 15 years old, minimum 1 oke of 25% dieldrin per donum.
> For trees over 15 years old, minimum 1½ oke of 25% dieldrin per donum.
>
> The required quantity of insecticide as above, shall be diluted in water and sprayed on the outer foliage of the trees. The dilution suggested is 16 drams of 25% dieldrin per 10 okes of water. (400 drams = 1 oke) Should 50% dieldrin be used, the above rates of dieldrin shall be reduced to one half.
>
> The treatment shall be carried out soon after September 20th, and not later than October 20th, unless otherwise prescribed by the Director of Agriculture by a notice in the Gazette."

Few exemptions are permitted and these are contained in successive clauses which are quoted below:

> "Gardens containing less than 10 orange and/or tangerine trees shall be exempted from these regulations.
>
> Growers whose trees, although over 4 years old, bear no fruit, may apply to the Director of Agriculture for exemption from these regulations.
>
> Should a grower fail to spray his trees as prescribed above, the Director of Agriculture may arrange for the spraying to be carried out by a commercial or government owned spray unit. The cost of such treatment shall be collected from the grower."

7/1 COLONIAL INSECTICIDES RESEARCH UNIT, PORTON, HALF-YEARLY PROGRESS REPORT, 1st APRIL- 30th SEPTEMBER, 1956

A.B. HADAWAY, C.I.R.U. Porton.

Sorption of Insecticides by Soils

It has been found that cumulative sprayings with dieldrin or DDT on an active Uganda soil do not influence the rate of sorption of fresh applications, although, of course, a progressive increase in the amount of insecticide present in the mud might lead to better biological effect after sorption.

Tests consisted of spraying blocks of the soil five times at monthly intervals with 100 mg/sq.ft. dieldrin or DDT. Each deposit disappeared, in general, at the same rate.

In earlier experiments, it has been shown that the rate of disappearance of insecticides from the sprayed surface of mud blocks of standard Uganda soil is, broadly, inversely proportional to humidity but once they are adsorbed their rate of diffusion away from the surface is directly proportional.

Further tests have been carried out with DDT and dieldrin on nine other tropical soils representing a wide range of activity. The humidity effect has been substantiated in each case, in that the rates of disappearance of the insecticides were much greater at 10% than at 90% R.H. At either humidity the same sequence of activity of the range of soils used was maintained but, whereas DDT and dieldrin disappeared from all the soils at 10% in a few days, at 90% the only deposits to be completely sorbed after 3 weeks were those of dieldrin on very active soils.

In order to determine whether the presence of iron in red coloured lateritic type soil might affect its sorptive properties is was decided to extract the iron from a standard red Uganda soil. Removal of the iron compounds however, did not significantly decrease the sorptive properties of the soil. The modified light grey soil adsorbed dieldrin just as effectively as the original, although the rate of DDT was diminished.

The Persistence of Insecticides on Various Materials

A series of experiments has been started to assess the persistence of dieldrin and DDT on a representative selection of materials used inside dwellings in tropical countries.

Preliminary investigations have been concerned with the sampling of deposits, and satisfactory recoveries have been obtained from bamboo and palm thatch. Wood has proved an interesting material but on two of the kinds used not more than about two thirds of the total dosage of insecticide could be accounted for as a surface deposit immediately after spraying. The rest was recovered from an outer layer of wood about one fiftieth of an inch in thickness. Presumably this represents particles which drop between the wood fibres as the insecticide is applied. A satisfactory method of using grass thatch as a test surface has not yet been resolved.

This investigation will supplement the data already obtained on the residual action of insecticides on soils used in exterior construction.

The Influence of Environmental Conditions on the Action of Insecticides

Following studies on the effects of temperature and humidity on the toxicity of insecticides to mosquitoes and houseflies during post-treatment, experiments have been started to determine the effects of environmental conditions, during treatment and during the pre-treatment period, i.e. during breeding.

It was first found necessary to determine changes in susceptibility of insects at different ages and in different nutritional conditions. With female houseflies, "continuous" feeders, at 25°C there is a decrease in susceptibility with age until they are 4-5 days old. The LD50 then remains fairly constant for a further week. On the other hand, the susceptibility of female mosquitoes, "intermittent" feeders, shows a definite cycle which can be correlated with the feeding cycle. Susceptibility is lowest 24 hours after each blood meal.

It has been found that pre-treatment temperature affects the metabolic rate in insects and thus the frequency of feeding in mosquitoes. Temperature during treatment appears to influence the rate of pick-up and penetration of insecticide, and so far higher kills have been obtained with higher exposure temperatures. The effect of humidity during the exposure period on the action of insecticides varies with different insecticides and with the different substrates to which they are applied, and further investigations are necessary. In this connection measurements have been made on the sorption of water vapour by various substrates over a range of relative humidities. There are marked differences in the behaviour of the surfaces tested, and these will probably help to explain the biological findings.

Rate of Evaporation of Solvents

The losses in weight with time of thin films of various solvents and solutions used in aircraft trials have been measured. These give some idea of the relative rates of evaporation of these solvents. For instance, percentages evaporated after 2 hours in still air and at room temperature were as follows: ASPA 21 (a spindle oil), 0,0; fuel oil, 5,6; K.E.B., 12.9; diesoline, 30,3; T.P.5007 (a solution of DDT in fuel oil; power kerosene, 1:4), 59,0; and power kerosene, 84,7.

Residual Toxicity of Insecticidal Deposits on Vegetation

A series of experiments has been planned to provide further information about the behaviour of low volume residual spray deposits such as might be applied from aircraft in the field, on leaves of different types, with special reference to tropical climatic conditions.

In the first of these reports which is included elsewhere in this issue DDT and dieldrin oil solutions and emulsions were sprayed in droplets of almost uniform size on to ivy and runner bean leaves and, for comparison, on to glass plates. The treated leaves and plates were maintained either in a constant temperature room or in a greenhouse.

Factors Affecting the Susceptibility of Mosquito Larvae to Insecticides

Experiments on the susceptibility to insecticides of *Aedes aegypti* at different stages of development have been continued. Comparison of the susceptibility of different larval age-groups to DDT and dieldrin has yielded some curious results. With 1-hour exposures DDT appears to be more toxic than dieldrin up to the 5th day of larval life. For the remaining 3 days before pupation the situation is reversed, and dieldrin appears the more toxic substance. With 24-hour exposures, DDT is slightly more toxic than dieldrin to larvae of all ages except those just about to pupate. It seems possible that the discrepancy is related to differences in the physical state of the two insecticides, for the concentrations needed to kill the older larvae after a 1-hour exposure were above the true solubility of these substances.

Subsidiary findings have been the importance of allowing the larvae a recovery period after short exposures if a valid assessment of mortality is to be obtained; the pronounced effects on mortality produced by the presence or absence of food before and during exposure; a reduction in mortality when the density of larvae in the insecticidal solution is above a certain limit.

It is hoped that the results will provide some of the data which will be needed if a reliable standard procedure for testing the susceptibility of mosquito larvae is to be formulated with a view to assessing the occurrence of resistance in natural populations.

Wind Tunnel Studies

With the help of the Anti-Locust Research Unit at Porton, the efficiency of droplet collection of some isolated spheres and a cascade impactor have been measured in a wind tunnel, using droplets varying from 50 to 160 microns in diameter, in winds ranging from 3 to 5 metres per second.

Under these conditions the collection efficiency of the impactor was found to be 70 ± 10%. It was also concluded that the collection efficiencies of the spheres were similar to those computed by Langmuir and Blodgett.

Spray Assessment Techniques

In aircraft trials it was found that the deposits on magnesium oxide coated glass plates, siliconed glass plates, filter papers and jump cards differed in a consistant fashion. Following this up, these and other surfaces were exposed to a fairly homogeneous spray in the Anti-Locust Research Wind Tunnel at Porton, and the relative deposits measured. Some understanding of the processes occuring was obtained in this way, and to add to it the collection efficiency of a horizontal siliconed plate, exposed in this tunnel, was measured.

Aircraft Application

(a) Auster J.5G Aircraft XJ941

A new boom and nozzle type of equipment has been designed, constructed and fitted to obtain finer sprays of insecticide than were possible with the standard Auster equipment.

(b) Britten-Norman Rotary Atomiser

Tests are being made on a new type of rotary cage or cylinder type sprayer developed by Messrs. Britten-Norman for use on aircraft. This type of atomiser which has already aroused much interest is generally regarded as being intrinsically suited to drift spraying research.

57/2 COLONIAL PESTICIDES RESEARCH UNIT ARUSHA, TANGANYIKA

Half-Yearly Progress Report No. 19. April - September, 1956.

1. Mosquito Spraying (Taveta-Pare)

The second spraying cycle was completed in June. In addition to the usual papers, checks have been made on the expenditure of insecticide suspension in houses of known internal area, both for individual houses and for the complete days' work by a team. The last type of check can be done without the knowledge of the team concerned and gives a measure of their consistency. These expenditure checks have proved extremely valuable, the papers of even the best sprayer giving a result 1.7 times the maximum possible with the known expenditure in the houses concerned. This is not necessarily deliberate. The best operator produces an extremely regular deposit and it would now appear that the papers give more information on the evenness of the spraying than on the true mean deposit. The best figure for the latter is probably obtained from the known expenditure corrected for the efficiency of the nozzles in use. In the present case this is thought to be about 75% and the mean rate of application has been satisfactory at about 0.4 gm/m^2.

A complication is the discovery that different batches of the pump nozzles differ in size. Not only is there considerable variation between nozzles in one batch but the mean emission rate for the latest consignment is only 75% of that of the previous one and there is no overlap. This makes standardisation very difficult.

A. funestus has disappeared from houses but a few can be found in box-traps, A.gambiae is very rare in Taveta and rare in the Pare area. Malarial transmission seems to have stopped, to judge by the infant parasite rate. No infected mosquito has been found since spraying started.

The estimation of wall and roof deposits of dieldrin during the 1955-56 spraying cycle for malaria control at Nandi, Kenya, and in the Taveta-Pare district of Tanganyika was recently completed. A test of symmetry for the deposits on sample papers from 151 Taveta-Pare houses showed that the distribution was positively skewed. Samples from 195 Nandi houses also had a positively skewed distribution and showed two distinct peaks in the frequency distribution curve. The two peaks could not be attributed to differences in mean deposits between the spray teams, or between different house sizes. The use of quality control charts as a check of spraying efficiency was invalidated by the abnormal distribution. The Taveta-Pare data was normalised by a logarithmic transformation, after which it was possible to use the control chart procedure.

The positive skewness was due to some very high deposits on the sample papers, possibly the result of deliberate overtreatment by the spraying personnel. Alternatively, some of the sprayers may have been affected unconsciously by the presence of sample papers.

2. Anopheles gambiae Resistance to Dieldrin in N. Nigeria

This is described in items 57/7 & 8. Dr. J. A. Armstrong, of C.P.R.U. Arusha, paid a 3-month visit to Nigeria to assist in the study of this phenomenon. (Ed.)

3. Mosquito Control in Dar es Salaam

During April–June, 1956, an attempt was made to prevent the seasonal increase in Anopheline populations that accompanies the long rains. Granules containing 0.02% (w/w) of dieldrin were applied at the rate of 1 lb per acre to the large seasonal breeding sites around the township of Dar es Salaam; about 5,000 acres were treated 7 times during a period of approximately 9 weeks, and 17 tons of insecticide were applied. The experiment was a cooperative effort of this unit, the East African Institute of Malaria and Vector Borne Diseases, the Medical Department, Tanganyika, and the Medical Officer of Health, Dar es Salaam.

No appreciable breeding could be detected within the treated areas, and in the township of Dar es Salaam the adult catches were very low compared with records of previous years. Records of the incidence of malaria were less encouraging. The analysis of the results is complicated by the fact that widespread ground control of mosquito larvae is carried out in Dar es Salaam, and houses are being treated with residual insecticides. It is considered wise, therefore, to defer a final assessment of the experiment until all records are complete and have been studied by the authorities concerned.

4. Cotton Pests

Details of the experiments at Urambo are recorded in more detail as item 57/9.(Ed.)

The persistence of DDT and endrin on cotton leaves was also investigated. Both insecticides were applied as emulsifiable concentrates. Since the final yield of cotton was important, leaf sampling was restricted to two rows in each plot. More representative samples would have been obtained by sampling across the rows. A sample of 30 leaves was taken from each of five replicate plots for each treatment. Leaves of about the same size were selected to give a mean surface area of 2540 sq.cm. per sample. Samples were collected at daily intervals for one week when the cotton was 15 weeks old. The insecticide was determined by the total chlorine (Stepanow) method. The mean initial deposit of DDT, resulting from the application of 1 lb of insecticide per acre was 6.45 mg/1000 sq.cm. Endrin, applied at thr rate of ¼ lb/acre, gave an initial deposit of 2.0 mg/1000 sq.cm.

The regression equation for loss of DDT was:-

$$\log_{10} r_{1}, = 0.83 - 0.61 \log_{10}(t+1)$$

where r DDT residue in mg/1000 sq.cm.
t time in days.

The regression equation for loss of endrin was:

$$\log_{10}(r_{2} + 1) = 0.46 - 0.45 \log_{10}(t+1)$$

where r_2 = endrin residue in mg/1000 sq.cm.

Rainfall during the sampling period was 0.61". The rate of loss of the endrin formulation was significantly greater than that of DDT.

The regression equations express total residue losses but it is probable that crop growth caused a greater reduction than weathering.

5. Maize Stalk Borer

The results of a series of trials against the Maize Stalk borer, Busseola fusca, at Mbulu, Northern Province, have now been completed. The bionomics and life-history of the insect has been described for that district. Yields confirm the conclusions that were drawn from infestation rates in the last report. Insecticide dusts gave exceptionally good control, endrin 2% dust giving the greatest reduction in infestation and increase in yield, followed by DDT 5%, DDT 2.5% and DDT 1% dusts. Endrin 0.05% emulsion spray was slso highly effective in comparison with DDT and gamma BHC sprays, and increased yields to 2.6 times the control. Yields in general were doubled, and in the order of 3,500 to 5,000 lbs/acre of shelled maize.

The timing and number of applications required to give an economic control was investigated, two sprays at high strength or three at a lower being necessary if the infestation is high.

6. Bean Fly

Experiments with seed dressings on beans have demonstrated the possibility of controlling the Bean fly, Agromyza (Melanagromyza) phaseoli. Dressing the seeds with small quantities of insecticide emulsifiable concentrates depressed germination to some extent but showed very clearly that aldrin, endrin and dieldrin were effective in completely preventing attack for four weeks after germination. The rate of dressing was approximately 0.2% of active ingredient by weight of seed.

Dry dressings of wettable powders or formulated seed dressings again proved aldrin to give complete protection for the same length of time, as also did gamma BHC dry seed dressings. Parathion, Dipterex (Bayer compound 4519), Diazinon and DDT were less effective. Owing to drought no yields could be taken.

7. Air craft Spraying of Pseudotheraptus wayi on Coconut Palms (Mafia Island)

DDT, (0.7 lb/acre), applied as a coarse aerosol at a nominal volume dosage of 0.25 gallons per acre, gave a kill of approximately 90%, whereas, 0.25 lbs of DDT per acre was much less effective. It appeared from the records of nut damage that two applications at the higher dosage would be necessary to reduce the bug population to a sufficiently low level, and that such treatments would have to be repeated at intervals of a few months.

8. Performance of Boom-and-Nozzle Installations

Prolonged safaris have prevented the completion of the analysis of data collected upon the performance of boom-and-nozzle installations fitted with Bray nozzles. A preliminary study has shown that further work will be required before a predictive technique can be found to cover a very wide range of conditions. Although it is possible to specify for many solutions the conditions for obtaining mass median diameters of from about 100 microns to 400-500 microns, the more general and converse requirement is not possible; namely, the prediction of droplet sizes for any given installation.

57/3 REPORT ON THE WORK AT ROTHAMSTED EXPERIMENTAL STATION, HERTS FOR THE COLONIAL PESTICIDES COMMITTEE, APRIL-SEPTEMBER, 1956

Methods of Bioassay

There are still some unsatisfactory features in the method used at Rothamsted to assay the toxicity of insecticide deposits by confining batches of Tribolium castaneum (Hbst) on the deposits for a period of hours. The variation in mortality between replicate batches is greater than is to be expected from random variation in the susceptibility of insects.

The method consists of confining groups of 10 T. castaneum on the test surface in glass rings for either 4 or 24 hours in the dark at 20°C, R.H. 60%. Four replicates are used for each level of deposit density. The insects are individually removed from deposits by means of a drawn-out glass tube attached to the vacuum line and transferred to specimen tubes. After 5 days at the same temperature and humidity, the dead are counted.

Previous work showed that variations in mortality are accompanied by variations in the amount of insecticide picked up by the insects. Also the variations in mortality were much reduced by exposing the insects to the deposits for 6 days and counting the dead at once. While possible causes of variation are being studied the technique of 6 day exposure is being used. Possible causes of variability are as follows:-

1. That insects are not selected at random from the culture. This is avoided by putting one insect at a time into each ring before putting the second into the first ring, etc.

2. That deposits are variable in character. When two successive batches of insects were exposed on the same deposit, an area causing a high kill in the first batch was followed in many cases by a low kill in the second. If deposits were irregular, it was expected that such an area would similarly give a high kill in the second batch. Thus variability of deposit is not considered to be the main cause of variability of kill.

3. That an occasional insect might pick up a dose much greater than average and transfer it to others during the storage period before mortality assessment. This factor was eliminated by the following experiment: Two sets, each of 10 batches of 10 insects, were exposed to a DDT deposit which would give about 50% kill. One set was removed and kept in the usual manner, the other was randomised on removal from the deposit, so that insects exposed as a batch were distributed among the ten batches during storage. The variability of kill in the randomised groups was much smaller than in the non-randomised and was no greater than to be expected on statistical grounds.

4. That insects within a group act upon one another during exposure in such a way that the mean amount of insecticide picked up is increased. This is being studied by exposing insects singly, and comparing both the mean kill and the variability with those obtained by the standard methods.

Effects of Various Additives on the Toxicity of Deposits from DDT Emulsions

Emulsions containing small amounts of additives which modify the crystal form are sprayed on wax-coated glass plates, with similar deposits from standard emulsions on wax-coated and on plain glass plates for comparison. The toxicity of these deposits has been measured by the 6-day exposure technique with *T. castaneum* mentioned above. So far, despite the considerable effect of the additives on crystal form no great differences in toxicity between standard and modified emulsion have been found.

Although the technique of long-exposure periods gives satisfactory precise results, it is likely to be insensitive to differences in rate of direct penetration and ease of pick up from the deposit. A technique giving reproducible results with short exposure times is being actively sought.

Rate of Evaporation of Insecticide Films

Reliable measurements of the evaporation rates of insecticidal films under standard conditions can only be obtained if the rate of ventilation is controlled. A ventilated cabinet in which the airflow is made laminar by a number of "honeycomb" screens has satisfactorily reduced variation in evaporation rates between test plates.

Using the wind tunnel, it has been shown that evaporation from emulsion-sprayed plates is linear with time until about two-third of the deposit has evaporated. At this stage most of the long out-growths from the centres of crystallization have been lost, and only compact clumps at the centres remain. Thereafter, evaporation continues at a lower rate. Recent results have confirmed that during the initial linear period of evaporation, the rate of evaporation was independent of the initial density of the deposit. For the conditions in the ventilated cabinet, i.e. 24-25°C and 8 m.p.h. wind-speed, the rate of loss is about 0.4 microgm/sq.cm/day.

57/4 WEST AFRICAN TIMBER BORER RESEARCH UNIT, REPORT FROM OCTOBER 1955 TO MARCH 1956

W. E. WEBB and T. JONES.

Work has continued on the biology of ambrosia beetles (Scolytidae, Platypodidae), in particular the study of flight periods.

An insecticidal trial was carried out in the field to determine the relative effectiveness against ambrosia beetle attack on logs of Triplochiton scleroxylon (Wawa) of formulations of aldrin, dieldrin, BHC and DDT at concentrations of 0.5% active ingredients. The overall ambrosia attack on control and treated billets was lower than in previous experiments and this made the assessment of relative merits of the treatments more difficult. Further investigations are necessary to substantiate the following conclusions.

Treatments incorporating gamma BHC were the most effective. Of four formulations used, a water miscible paint OBD.5 gave the best results. The paint, which on drying becomes water resistant, should give protection for at least 10 weeks under the wet conditions normally encountered in W. Africa. The application of OBD.5 at 0.5% gamma BHC was equally effective on logs with and without bark.

Aldrin and dieldrin produced contrasting results depending on the diluent and carrier used, and the state of the logs. The effectiveness of dieldrin in oil on debarked billets closely approached that of OBD.5.

DDT water emulsion is not recommended. The non-insecticidal compounds, AG.2005 and fuel oil, gave no protection and appeared to increase the attractiveness of treated billets to ambrosia beetles, particularly when applied directly to the bark.

57/5 BITING FLY RESEARCH PROJECT, ENTEBBE, UGANDA. PROGRESS REPORT 1st APRIL - 30th SEPTEMBER 1956

H.C.M. PARR, Entomologist-in-Charge.

Field investigations indicate that Stomoxys breeding does not occur extensively in dung or manure heaps, but takes place in rotting vegetation, which is probably contaminated with dung and/or urine. Commencing at the next wet season, more detailed investigations of breeding places are envisaged, including temperature, pH, moisture content and composition of the media, as well as ecological, population, and behaviouristic studies of adult flies.

The establishment of a semi-permanent camp and field laboratory at Lubale, S.Ankole, is suggested. The nearby area would be eminently suitable for fly investigations, and also for later work on mechanical transmission and fly control. It is considered that the farms and research stations visited in the past represent an artificial environment not met with in the vast majority of African owned cattle in Uganda. Breeding places discovered on government farms will normally be immediately dealt with, thus upsetting any programme of sustained observations.

A laboratory colony of approximately 2000 adult Stomoxys calcitrans is maintained. Daily records of numbers of pupae collected, hatching adults, and death of adults are kept. Experiments are in progress to investigate the percentage hatch of pupae, the number of eggs laid at different times during the day, and the duration of larval instars and instar morphological characters. In addition, a large fly proof cage has been built for mechanical transmission experiments in the laboratory. A colony of Glossina morsitans is to be established to maintain a strain of Trypanosoma congolense in rats.

57/6 ANNUAL REPORT OF THE MALARIAL CONTROL PILOT PROJECT IN WESTERN SOKOTO (NORTHERN NIGERIA) 1955-56

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The report covers the entomological, malariological and chemical investigations during the second year of the fully established Project, from April 1955 to March 1956. The chemical aspects of the three insecticides used in the Project area appear in an Appendix.

The total Project area* of approximately 600 sq. miles now contains about 86,000 dwellings inhabited by 124,000 people. Total costs of the Project amounted to nearly three shillings per head of the protected population per annum.

*A map of the Area is appended.

1. Chemical Investigations

The chemical investigations (Appendix 1) relate to testing of the applied formulations, to estimation of dosages sprayed in the field, and to the persistence of insecticidal deposits on treated surfaces.

The formulations selected for this work were water dispersible powders containing 75% technical DDT (75% pp'), 50% dieldrin and 50% BHC (6.5% gamma) and recently 50% lindane respectively. All were tested to WHO specifications and in one case only was material not found satisfactory.

The dosage of insecticides delivered on to surfaces has been checked by (a) exposing sheets of absorbent paper to the spray and (b) by sampling the treated surface immediately after spraying The assessed dosages have been found to vary, generally in excess of the required concentration.

Mechanical scraping, or occasionally adhesive tape, was used to sample wall deposits. Estimation of the insecticide was made for DDT by the Schechter-Haller (modified by Barlow) or by a modification of the Alessandrini method. Dieldrin and BHC were examined by a semi-micro Stepanow technique, the chloride being determined amperometrically.

The persistence of the three insecticides on the mud walls was investigated and it was found that within first two weeks after spraying the loss from the half millimetre of the surface amounts to about half of the initial deposit of the toxicant. After the first two weeks dieldrin and DDT show a decreasing loss but BHC continues to disappear at the same rate and after 5 weeks only 10% of the original BHC deposit remain on the surface. The loss of BHC is probably due to evaporation while the loss of DDT and dieldrin is primarily due to diffusion into the wall with consequent inactivation. This diffusion into the wall slows down the rate of loss of succeeding application of DDT and dieldrin while BHC shows no enhancement of residual life through superimposition of successive dosages. White-washing of mud walls does not enhance the duration of residual deposit of any of the three insecticides.

2. Spraying Operations

Spraying operations continued in 6 monthly cycles commencing in April and October. The dosage rate of DDT and BHC
00 mg/ft. remained at ~~2.0 gm.~~ para-para DDT per sq.ft. and ~~0.25 gm.~~ gamma /25 mg
isomer BHC per sq.ft. The dieldrin zone was divided into
5 mg/ft. 2 subzones receiving ~~0.25 gm~~ per sq.ft. and ~~0.5 gm.~~ per sq.ft. /50 mg
respectively.

The life of a new consignment of 48 Hudson 710 SC compression sprayers is estimated at 6 months. The sprayer suffers from the following defects:

(a) Constant pressure is not maintained, so that frequent recharging of the pump is necessary.

(b) The pump cylinder tends to collapse with over-pumping.

(c) The plunger cup made of synthetic material is less durable than the leather cup of the previous model.

3. Malariometry

Malariometric data was largely obtained from infants and children. It indicated that transmission of the diseases was more than halved in the Project area during the first 6 months of the 1955-56 year. The trend was reversed during the second half of the year and transmission went up again to the 1954-55 level. This was correlated with the appearance of the resistance in *Anopheles gambiae*.

The degree of tranmission throughout the year was greatest in the 25 mg. per sq.m. dieldrin zone and lowest in the DDT zone.

4. Entomology

Routine investigations continued as in the previous year. (PANS 1, (4)).

4.1 Anopheles Density Index. Mean Room Density Indices of *A.gambiae* in the whole Project Area were 1/9th of the Check Area during the dry and wet season of 1955, but early in 1956 the differences became less pronounced. It appeared that control was relatively more effective in the DDT zone.

TABLE I

Mean Room Density Indices of A.gambiae for the three insecticide zones and the check area

Period	Dieldrin zones (combined)	DDT zone	BHC zone	Check Area
Dry season 1955	2.7	0.07	0.3	10.3
Wet season 1955	16.1	5.4	2.4	93.3
Jan. - Mar. 1956	7.2	0.04	0.4	4.0

Anopheles identified as A.funestus probably contain a proportion of species other than A.funestus funestus and which are of no importance as human malaria vectors.

TABLE II

Density of "A.funestus" series in 1955

	Project Area	Check Area
Dry Season	0.9	6.7
Wet Season	1.7	14.6

4.2 Infectivity of Anopheles. The sporozoite rates for the whole period in the Project Area compared with the Check Area were 1.25% against 1.8% for A.gambiae and 0.2% against 0.9% for A.funestus.

The respective annual sporozoite rates in the separate spraying zones for A.gambiae were 0.2% (DDT), 1.2% (BHC), and 1.4% (dieldrin).

The Average Infective Density (calculated from the sporozoite rate and the room density index) for A.gambiae gave the inoculation rate (number of infective bites per person per year) as 18 in the Project Area and 146 in the untreated Check Area. The ratio of these figures (8:1) is much higher than the respective ratio of 2.3 obtained from the comparison of inoculation rates (Project Area = 1.51 per yr; Check Area = 3.5 per yr) calculated from the parasite rates of examined infants.

Malaria transmission in Western Sokoto is highest between July and December and very low between January and June.

4.3 Habits of Anopheles. Investigations of indoor resting habits show that about 60% of *A.gambiae* females rest on the inside of the thatched roof, 20% on mud walls, and an average of 20% rest on calabashes and other household articles. Numbers of *A. gambiae* and *A.funestus* collected in outdoor shelters were small. Other *Anopheles* collected, in decreasing order of frequency, were *A.squamosus*, *A.pharoensis*, *A.rufipes*, *A.coustani* and *A.welcomei*. Culicine mosquitoes were frequently found in outdoor shelters.

Outdoor biting activity of *A.gambiae* may reach 30% of indoor biting frequency. The peak of biting activity seems to be about 3-5 hrs. before dawn.

Host preferences investigated by precipitin tests indicate that while *A.gambiae* is highly anthropophilic it will also feed on horses and cattle.

5. Resistance

Early results showed that *A.gambiae* from the dieldrin zone became, after 18 months, at least 8 times more resistant to dieldrin than the still susceptible strain in the unsprayed areas.

Further experiments at the Ross Institute, London have confirmed the presence of dieldrin resistance in *A.gambiae* from W.Sokoto, with a high cross resistance to BHC. No enhancement of DDT resistance was found.

TABLE III

Median Lethal Concentrations of various insecticides when two strains of A.gambiae (females) are exposed for 1 hour. (Quoted after Davidson (1956), Nature, London, 178, p.705.

Insecticide	Lagos strain (susceptible)		Ambursa strain (W.Sokoto resistant)	
Pyrethrins	0.4	(138)	0.8	(302)
DDT	0.6	(201)	0.6	(97)
Malathion	0.8	(60)	1.4	(50)
Gamma BHC	0.007	(177)	0.18	(62)
Dieldrin	0.08	(831)	no kill at 4%	
Aldrin	0.2	(142)	no kill at 4%	

Note:- Figures in brackets refer to number of female mosquitoes exposed.

Preliminary genetic analysis (communicated by Prof. G. Macdonald, Ross Institute) indicates the resistance is by Mendelian inheritance of two alleles, one conveying the normal susceptibility and the other the increased resistance. Therefore a "resistant" population would consist of three more or less distinct groups: susceptible, fully resistant, and hybrids of the two.

57/7 REPORT ON A FIELD INVESTIGATION INTO THE EXTENT AND DEGREE OF INSECTICIDE RESISTANCE IN ANOPHELES GAMBIAE IN THE AREA OF THE WESTERN SOKOTO MALARIA PROJECT

J.A. ARMSTRONG, C.D. RAMSDALE, V. RAMAKRISHNA.

The survey was made from September to November, 1956. Annual Reports (PANS "A", 1, (4) & 3, (1)) give the history of spraying in the Project Area until March 1956. After this, the period between sprays in the BHC zone was cut from 6 to 4 months. In April 1956, part of the dieldrin zone formerly sprayed with dieldrin at 50 mg/sq.ft. was sprayed with BHC at 40 mg/sq.ft.; the remainder of the dieldrin zone except the town, Gwandu, was sprayed with dieldrin at 50 mg/sq.ft.

Between May and July 1956, an extension area and Gwandu were sprayed with BHC at 40 mg/sq.ft.

Physiological resistance to dieldrin in A.gambiae was reported in November 1955.

Survey Methods

Adult mosquitoes were obtained by hand catching of adults in houses, and by breeding out of adults from wild caught larvae. They were taken to a central point and tested by the Busvine technique. The degree of dieldrin resistance was determined by exposure to 0.5% and 4.0% dieldrin*. Table I reveals a high level of resistance in the Pilot and Extension zones, and a potential resistance at Diggi, about 12 miles from Birnin Kebbi on the border of the dieldrin zone.

TABLE I

Area	Proportion		
	Susceptible	Heterozygous Resistant	Homozygous Resistant
Pilot area (excluding DDT)	9% (418)	2%	89% (805)
Extension area	8% (72)	2%	90% (85)
Diggi (unsprayed)	99.96% (2666)	0.04%	0% (1336)
Sokoto (unsprayed)	94% (170)	6%	0% (102)

(Figures in brackets refer to numbers of mosquitoes employed).

No relation was found between the house density of mosquitoes and the level of resistance.

Throughout the Pilot zone, dieldrin and BHC resistance were found to be linked, but this bore no relation to DDT mortalities.

The mortalities of wild caught adults and bred out material showed that the proportions of dieldrin and BHC resistants in the population is uniformly high thoughout the area.

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* Davidson, G., (1956). Nature, 178, pp.863-864.

A few A.gambiae found on the borders of the DDT zone have probably entered from adjoining areas, since DDT is effectively controlling the mosquitoes within the rest of the zone.

57/8 INVESTIGATIONS ON THE TOLERANCE OF INSECTICIDES BY ANOPHELES GAMBIAE, GILES, IN NORTHERN AND WESTERN NIGERIA

R. ELLIOTT and J.A. ARMSTRONG.

This report covers observations in October and November 1956 of the level of resistance to insecticides in A.gambiae from four localities: Kano (N.Nigeria), Lagos, Ilaro and Ibadan (S.W.Nigeria).

Kano

From 1950 onwards, residual insecticides, DDT and BHC, have been variously used in the airport buildings, and fortified larvicides in the control perimeter.

The first indication of possible resistance came in October 1955, when mosquitoes were found resting on wall surfaces recently sprayed with BHC emulsion. On testing, the emulsion concentrate was completely up to specification as regards BHC content. Attempts to collect and test resting A.gambiae at this time were unsuccessful.

A consignment of eggs sent from N.Nigeria to London, instead of giving rise to normally dieldrin susceptible mosquitoes, gave only 25% susceptible, the rest being either homozygous or heterozygous resistant material.

As a result, tests (summarised in Table I) were carried out on wild-caught blood fed and gravid female A.gambiae collected 7 miles from the airport.

TABLE I

Concentration of dieldrin	Number exposed	Percentage mortality	Corrected percentage mortality
4.0%	22	72.7%	70%
0.5%	71	92.9%	92%
control	45	6.6%	-

The conclusion is that in the majority of samples tested there are between 90% and 50% homozygous susceptible A.gambiae. Resistance at Kano of the type found in W.Sokoto appears to have arisen independently through stress by BHC.

Lagos

DDT has been used as a larvicide almost since its first introduction, initially as a fortified gas oil larvicide and later as Freetown Emulsion. Imagicides, principally DDT, have been used on a small scale.

Unfed females bred from larvae or eggs collected from natural sources were tested against DDT when 24-48 hrs. old. A high control mortality made the findings a little unreliable, but an LD_{50} of 0.6% DDT and a high mortality at 2.0% DDT suggest that no resistance to DDT has so far developed. No tests on dieldrin susceptibility are reported.

Ilaro

Under the **Ilaro** Experimental Malaria Control Scheme, eleven quarterly spraying cycles, with BHC wettable powder at 10 (and later 15) mg.γ.isomer/sq.ft., were completed between March 1950 and January 1953. In the three years, the reduction of A.gambiae density index was 93%, 88%, and 84%. The continued presence of A.gambiae could be accounted for by infiltration at the perimeter of the area.

However the possibility of physiological resistance was investigated by exposing unfed females, bred from field collected larvae, to DDT and BHC on the day of emergence. The LD_{50}'s (in brackets) for BHC (0.006%) and DDT (0.6%) are close to those obtained by other authors for susceptible material. Again no tests using dieldrin are reported.

Ibadan

There has been no large scale use of residual insecticides. No figures for LD_{50} 's have so far been obtained due to high control mortalities in the tested mosquitoes.

The evidence suggests that the mutant gene conferring resistance to BHC and dieldrin described by Davidson has not so far appeared in the South. The possibility is discussed of different strains of *A.gambiae* existing in the North and South of Nigeria.

57/9 REPORT ON THE CONTROL OF COTTON PESTS AT URAMBO, WESTERN PROVINCE, TANGANYIKA, SEPTEMBER, 1955 - SEPTEMBER, 1956

K.S. McKINLAY.

At Urambo, in the Brachystegia/Isoberlinia ecological zone, it is impossible to grow cotton without encountering severe cotton stainer attack. Trials were planned for the control of cotton stainers, but termites and the American bollworm, *Heliothis armigera*, proceeded a heavy attack of the stainer *Calidea dregei*, and would have caused complete loss of crop if extra measures had not been taken.

Termites attacked the plants soon after they started to grow. Control with γ-BHC at $\frac{1}{4}$ lb/acre applied as 30 cc. spray to the plant base was slow but almost complete. Trials with aldrin hannane and BHC at $\frac{1}{4}$ lb/acre and DDT at 1 lb/acre similarly applied were equally effective whether poured on the soil or injected to a depth of two inches. Aldrin, $\frac{1}{4}$ lb/acre, applied to the soil before planting gave almost complete protection.

Bollworm attacked the flower buds from late February to end of March, and *Calidea* from the end of March to the end of May. *Calidea* were difficult to control because of their extreme mobility and comparative resistance to insecticides. Also *Aphis gossypii* increased towards the end of the season.

The following seven treatments were applied 6 times at weekly intervals against bollworm attack, at 12 gals/acre using knapsack sprayers: endrin, DDT, BHC, dieldrin each at $\frac{1}{4}$ lb/acre/application, DDT at 1 lb/acre/application; BHC, $\frac{1}{4}$ lb + DDT, $\frac{1}{4}$ lb and 1 lb/acre. DDT at 1 lb/acre gave approximately 90% reduction in the number of damaged buds/20 plants. Addition of $\frac{1}{4}$ lb BHC gave no significant difference. Endrin gave reasonable control.

Subsequently DDT, 1 lb/acre was applied weekly against *Calidea*, with addition of $\frac{1}{4}$ lb BHC/acre when aphis population increased.

Yield of cotton seed was 1154 lb/acre from treatment blocks receiving 1 lb DDT/acre against bollworm and Calidea, but only 145 lb/acre blocks similarly treated against bollworm only.

It was concluded that weekly applications of 1 lb DDT/acre for about 12 weeks would control bollworm and Calidea, plus $\frac{1}{4}$ lb BHC/acre if necessary to control Aphis. Yields up to 1500 lbs seed cotton/acre can be expected if cotton is well grown and pests are controlled.

Two things are essential if cotton is to be a profitable cash crop in the area. Firstly the cotton must be well-grown to ensure potential yields sufficiently large to stand the cost of insecticides and secondly the sprays must be properly applied. Unless this is done an attempt at growing cotton in these areas will fail. This would mean that before cotton could be grown by the African some form of advisory and spraying organisation would have to be set up.

In general cotton growing in these areas would be very troublesome but if the need for a cash crop were sufficiently great and a proper organisation set up, it could be a profitable crop at present prices.

57/10 PRELIMINARY REPORTS ON THE INSECT PESTS AT MANANGA, SWAZILAND

K.S. McKINLAY, Entomologist, c/o Swaziland Irrigation Scheme. 1956.

Mr. McKinlay has recently been seconded to Swaziland from Tanganyika. The following pests have been found on the crops indicated.

Potato: Cutworm larvae, False wireworm.

Maize: Cutworm larvae.

Cotton: Cotton aphid, Spiny Bollworm, Red Bollworm, Stainer nymphs.

Rice: (ratoon crop).

1. Stem borer, Ampycodes pallidicosta
2. Rice beetle, Trichispa sericea
3. A dipterous larva which, in habits at least, resembles Chlorops cryzae
4. A lepidopterous larva resembling Sesamia inferens in habits and appearance.

As far as can be judged at present, the life history of Ampycodes is probably as follows: Moth lay eggs on the young rice early in the season and these develop to give rise to a second generation later on the older rice. The second generation pass the winter dry season as larvae in the rice stubble. The larvae are found inside the stems and as far down as they can get. Since the stems and tillers of a plant form a tight clump of roots the larvae are in a well protected situation one or two inches below soil level. These larvae will give rise to the moths which produce the first generation in the coming season. The practice of rationing rice at Mananga may have caused the pest to build up over the past few years.

Citrus: Under local conditions the following pests can be very serious.

1. Red scale, Aonidiella aurantii
2. Soft Brown Scale, Coccus hesperidum
3. Citrus aphis, Aphis taveresi del G.

The following insects also occur.

4. Oyster Scale, Lepidosaphes pinnaeformis
5. Fruit flies, Ceratitis capitata and Pterandrus rosus
6. Citrus thrips, Scirtothrips aurantii Faure.

Fruit flies are successfully controlled by poison baits. The most important pests are the scale insects. At present the recommendations of the Citrus Stations of S. Africa are being followed. In general, the recommendations are run off sprays of 0.075% Parathion and 0.075% Malathion applied at 75-100% petal fall, and repeated once again after six weeks. Sprays are applied with hand lances operating at 300-400 p.s.i. An additional spray of a systemic insecticide (Octamethylpyrophosphoramide) is also being applied to control Aphis on new growth.

Plans have been made for insecticidal trials for the control of the chief pests of citrus, rice, maize and cotton.

57/11 VETERINARY SERVICES - SOMALILAND PROTECTORATE ANNUAL REPORT 1951. (Extract)

The most popular function of the Veterinary Section is the treatment of trypanosomiasis in camels with "Antrypol" (Suramin B.P.) The standard dose is 3 gms. More camels were treated this year than ever before. "Antrycide" has now been established as a satisfactory cure for trypanosomiasis in the Somali camel. The tolerated average dose was rather smaller than expected (1.5 gms. per camel); relapses have not been reported so far. The immediate reaction is more acute than with 3 gms. of "Antrypol"; this appears to be a point in its favour as the people (like many farmers at home), like a medicine that produces an obvious reaction in administration.

Skin diseases and ectoparasites are treated in the sheep dips and by spraying. Two new Cooper's pumps are in use; they are most effective. Before their arrival stirrup pumps did good work. Arsenical dip is still used but it is gradually being replaced by Gammatox. Gammatox dip paste, which is effective in the hard-water areas of the east, had been shipped into the Protectorate for the first time. Sulphur ointment, BIPP, coal-tar disinfectant and phenothiazine are supplied on repayment for the treatment of skin troubles, minor injuries and other complaints. Individual treatments, except of European-owned dogs and ponies, are rare.

Kenya Attenuated Goat virus (KAG) was used on a large scale for the first time this year. It was initially given free in order to popularise it. Subsequently a charge of one shilling per head was levied. A further attempt was made to introduce bovine pleuro-pneumonia vaccine. Five hundred doses were offered free but only a very few cattle were allowed by their owners to be done. The vaccine was obtained from Kenya; it caused only minor reaction. Anthrax vaccine was in limited demand for camels and the usual annual injection of horse sickness vaccine for European and Government-owned ponies and mules was given. Rabies has been reported during the year but could not be definitely confirmed. A rigorous campaign to poison hyenas, jackals and pie-dogs in the suspected areas was carried out. Stock inspectors always carry strychnine and their destruction of vermin throughout the country is much appreciated.

57/12 EXPERIMENTS ON THE RESIDUAL TOXICITY OF INSECTICIDAL DEPOSITS ON VEGETATION

A.H. PARKER and F. BARLOW. Colonial Insecticides Research Unit, Porton. Report No. 120. July, 1956.

These laboratory experiments are the first of a series designed to provide information about the behaviour of low-volume residual spray deposits, such as might be applied from aircraft, on leaves of different types. Some attempt was made to simulate tropical climatic conditions. DDT and dieldrin oil solutions and emulsions were sprayed on to two types of leaf, and, for comparison, on to glass plates.

Methods

As examples of leaves with thick and thin cuticles, ivy and runner beans were chosen. Since treated leaves were to be kept for several weeks it was desirable to eliminate growth in size. The petioles of the first pair of leaves from potted bean plants were treated with the growth substance 3-indolylbutyric acid. The leaves rapidly developed roots and were planted in pots in a greenhouse. They lived up to three months without perceptible increase in size. Ivy leaves treated with 1-naphthyl-acetic acid failed to root, and, therefore, non-rooted ivy leaves collected in the field were kept alive for over two months by standing in water.

Recrystallized pp' DDT and dieldrin were used at 5% concentrations both as oil solutions and emulsions. The insecticides were applied in droplets of almost uniform size at dosages of 2-10 mg/sq.ft. the treated leaves were kept either in a constant temperature room at 25°C or in a greenhouse. The toxicity of leaf and plate surfaces was estimated biologically at intervals after treatment by use of *Aedes aegypti* females; some chemical estimations of the insecticides on the surfaces and in the remainder of the leaves were also carried out.

Results

Comparison of DDT and Dieldrin Deposits. As shown in Table I, the dieldrin treated surfaces were more toxic than the equivalent DDT surfaces.

TABLE I

Toxicity of residual deposits on glass plates and runner beans kept in a greenhouse in Summer.

Oil solutions applied at 4.2 ± 0.8 mg/sq.ft.
Emulsions applied at 2.5 ± 0.7 mg/sq.ft.
Results expressed as median lethal times of *Aedes* famlaes, in minutes.

Nature of Surface	Treatment	Age of deposit (weeks)				
		1	2	4	6	8
Glass plates	DDT oil solution	38	>128	>128	>128	>128
	Dieldrin oil solution	21	60	>128	>128	>128
	DDT emulsion	>128	>128	>128	>128	>128
	Dieldrin emulsion	85	>128	>128	>128	>128
Bean Leaves	DDT oil solution	45	60	120	>128	>128
	Dieldrin oil solution	14	20	53	60	115
	DDT emulsion	66	>128	>128	>128	>128
	Dieldrin emulsion	24	38	105	>128	>128

A similar, though less pronounced result, was obtained with ivy leaves and glass plates kept in the constant temperature room. Chemical estimations of the insecticides from dieldrin treated leaves indicated that it was less persistent than DDT. It therefore seems likely that dieldrin exhibits a greater inherent toxicity than DDT, rather than a longer persistence.

Comparison of Oil Solutions and Emulsions. Difficulty was encountered in obtaining equal dosages of oil solutions and emulsions but experiments in which either one or the other formulation was applied in excess gave no indication of any difference in persistence that could be attributed to the type of formulation.

Chemical analyses of the insecticide extracted from leaves after the surface deposit had been washed off gave values of up to 12% of the original dosage with bean, and up to 59% (DDT) with ivy. Differences in the values obtained with oil solutions and emulsions were for the most part slight and were not consistent. The amount extracted from the ivy leaves showed some tendency to increase with time since treatment. There was an indication that, as the insecticide on the surface of the bean leaves declined to vanishing point, that in the interior also disappeared.

Persistence. The deposits on bean leaves kept in the greenhouse during the summer persisted longer than those on similarly treated glass plates, presumably due to the higher temperatures to which the latter rose. Deposits on ivy leaves kept in the greenhouse during the autumn, or in the constant-temperature room, persisted to approximately the same degree as did those on similarly-treated glass plates.

Deposits on leaves and plates kept in the constant-temperature room were more persistent than those on equivalently-treated surfaces kept in the greenhouse during either the summer or the autumn; this again was probably at least partly a temperature effect.

57/13 MAIZE STALK BORER TRIALS, MBULU, TANGANYIKA, 1955-1956

P.T. WALKER.

Mbulu is a hilly district (altitude 5,700 to 6,000 ft) where maize is the main food crop. A high stalk borer infestation occurs, the predominant species being Busseola fusca.

The final instar larvae of B.fusca passed the dry season in the dead maize stalks used as 'trash bunds" along the hill contours for soil conservation. Pupation (lasting c. 28 days) was initiated at the onset of the rains in November, and two distinct generations of eggs appeared during the rainy period.

For these trials, maize was planted when rain was imminent to obtain the maximum infestation possible. Small experimental plots were mostly laid out in randomised blocks and treatments replicated at least three times.

Trial (a) Dusts

Endrin 2%	(3.7 oz ai./acre)	0.5%	final infestation	4740	lbs/acre yield
DDT 5%	(8 oz ")	4.5%	"	4347	"
DDT 2½%	(7.2 oz ")	5.0%	"	3956	"
DDT 1%	(2.8 oz ")	6.5%	"	3767	"
Control	-	42.0%	"	2583	"

Notes: ai. = active ingredient; LSD = least significant difference.

Dusts applied twice at a ten day interval, five days after first eggs hatched, at 12-15 lbs/acre, according to dust. LSD = ± 690 lbs/acre. The increased yield factors, taking control yield as unity, are:-
Control- 1, DDT 1%- 1.5, DDT 2.5%- 1.5, DDT 5%- 1.7, endrin 2%- 1.8.

No significant difference is demonstrable between DDT 1% and 2½% dusts, between DDT 2.5% and 5% or between DDT 5% and endrin 2%.

Trial (b) Sprays

Endrin 0.03%	(0.755 oz/acre ai.)	7.5%	infestation	3418	lbs/acre yield
DDT 0.05%	(1.24 oz ")	30.5%	""	2276	"
γ BHC 0.02%	(0.5 oz ")	32.0%	"	2164	"
Control	-	48.0%	"	1304	"

Sprays, emulsions, applied as top sprays at 15½ gallons/acre, twice with ten day interval, six days after first eggs hatched. LCD = ± 658 lbs/acre. Increased yield factors are:-
Control-1, γ BHC- 1,66, DDT- 1.7, endrin- 2.6

There are significant differences in response between all treatments and the control, between endrin and DDT, but not between DDT and γ BHC.

Trial (c) Timing

	Variety i		Variety ii	
	Infestation	Yield	Infestation	Yield
DDT 0.05% x 3 applns.	5.3%	4302 lbs/acre	7.4%	3210 lbs/acre
DDT " x 2 "	10.7%	3930 "	12.8%	3110 "
DDT " x 1 "	35.7%	3307 "	27.9%	2661 "
Control -	34.2%	3235 "	42.7%	2230 "

Sprays, emulsions, each at 12 gallons/acre= 1.0 oz ai./acre, applied as above but at nine day intervals, the first one day before eggs hatched. LSD's are ± 617 (variety i.) and ± 398 lbs/acre (variety ii). Increased yield factors are:-
i. Control-1, DDT x 1- 1.02, DDT x 2- 1.21, DDT x 3- 1.34
ii. Control- 1, " 1 1.19, " 1.39, " 1.44

Statistically, there is not only a recognisable difference between one and two applications of spray in both varieties, but also a difference between one application and the control in the case of variety ii.

Trial (d) Volumes and Rates

DDT 0.094%	(11 gall/acre)	= 1.65	oz ai/acre	7%	infestation	3294	lbs/acre
DDT 0.03%	(6½ ")	= 0.325	"	14%	"	2865	"
DDT 0.094%	(6½ ")	= 0.975	"	23%	"	2802	"
Control	-	-		28%	"	2285	"

Sprays, emulsions, applied as above. Plot variability was so great that no statistical differences could be detected. Increased yield factors are:-

Control- 1, DDT, upper and lower strength, lower volume, -1.24
DDT, upper strength, upper volume, -1.4

Trial (e) Candidate Insecticides

Small unreplicated trials with some recently developed insecticides were put down to give an indication of their possible future use. Two sprays with a 2 week interval between applied as emulsions at 0.05% ai and 15 gals/acre. Diazinon and Malathion gave a high initial kill and were effective for a week to ten days after the last spray, while DDT sprays were still effective twenty days after the last spray. DDT + resins was slightly more effective in controlling infestations than DDT emulsions alone.

57/14 FIELD TESTS FOR TERMITE RESISTANCE

W.V. HARRIS. Officer in Charge, Colonial Termite Research Unit. Abstract from Colonial Building Notes No. 39, September 1956.

Termite resistance to various types of timber and wood preservatives can be investigated locally with small scale trials such as termite graveyard tests.

Proving the Site

The site should have an adequate supply of wood feeding termites available and should be situated where the attack will not be too slow. Vegetation is cleared and the site levelled.

Slabs or stakes of timber known to be eaten freely by the local termites are partially buried in the soil at regular intervals. Deal or Eucalyptus Saligna are satisfactory. In dry weather, attack is accelerated by watering the plot or providing a light cover of grass or wood shavings, though care must be taken to avoid rotting the specimens. When over 75% of the slabs are damaged, slabs are removed, and the time for this stage to be reached is used as a minimum for subsequent trials. Three months in Africa will generally suffice.

Test Procedure

Test samples of uniform size (3" square stakes or 1" x 6" x 6 to 12" planks) marked with metal labels are buried two-thirds deep in soil. A "Latin Square" arrangement (Fig.1) might be used.

A	B	C	D	E
B	E	A	C	D
C	D	E	A	B
D	A	B	E	C
E	C	D	B	A

Fig.1

Each letter represents a different test specimen or untreated control. The suggested layout if only one kind of timber is under test is:

A - Deal or local timber known to be attacked

B and D - Untreated test timber.

C and E - Treated test timber.

Watering the soil in dry climates will help to attract termites and keep away ants. Test materials which deteriorate rapidly under extreme climatic conditions may be protected with light grass shelters or perforated tins. Disturbance of the specimens before final inspection should be avoided.

Results may be simply expressed by placing specimens in one of the following categories:

1. Undamaged.
2. Superficial attack only, obviously discontinued.
3. Damaged.

Ancillary Data

Brief notes of the climate during the trial period will be of value. Termites shaken from the slabs at inspection can be preserved in spirit or formalin, and sent for indentification to the nearest agricultural entomologist or to the Colonial Termite Research Unit, c/o British Museum (Natural History), Cromwell Road, London, S.W.7.

57/15 WEAVER BIRD (QUELEA) CAMPAIGN 1955-56 SEASON

CCTA/CSA Report from African Headquarters, Bukavu.

This report contains details of large scale aerial spraying conducted by the Ministry of Agriculture in S. Africa against breeding roosts of Quelea (finches).

The operation has been described as vastly superior to the conventional dynamite/fuel method in speed of application, mobility and within saving in costs estimated at approximately 75%. The campaign was conducted over a period of four months which was longer than anticipated on account of an extended breeding season.

Breeding times and centres were so distributed that it was possible to treat 43 colonies with a single aerial unit supported by ground supervisory staff. It is estimated that a total of at least 56 million Quelea were destroyed between mid January and the end of May at a total cost, including reconnaissance, of about £30 per acre. (Of this amount £20-14-0 is the charge against the poison (parathion based) and £6-0-0 for application).

Avicides

DNOC. Dinitro-ortho-cresol (D.N.O.C.) was tried in preliminary tests. Caged birds were sprayed at the rate of 10 gallons per morgen (equivalent to about 2 acres) after noon with a 20% DNOC. Mortality was 100%. When natural roosts were sprayed during the night however, at 20 gallons per morgen with the same product on field scale only 25-30% mortality was obtained.

It has since been found that (a) screening by the leaves diverts a lot of the poison, (b) high temperature of the summer day increases mortality. Caged birds placed under trees and sprayed with a 20% DNOC showed 45% mortality during the afternoon at a temperature of 85°F over 2 hours.

A great many birds were observed (with the characteristic yellow D.N.O.C. stain) two days after spraying a colony with DNOC. They did not appear however to have suffered any ill effects. The failure of DNOC in night application is attributed to lower air temperatures during spraying and initial exposure.

Parathion. Parathion was the selected poison in the aerial campaign since this material in one form or another has been shown to be the most effective contact spray. It was purchased under various trade names including Folidol, Fosferno, Parafos, etc. containing proportions of the active ingredient.

It has been found that different preparations differ in their killing power even if used at the same concentration. Certain preparations for example containing 50% parathion kill less than others containing 25% parathion even when used at the same rate. The reason is presumably to be sought in the variations of solvents, emulsifiers and stickers. It was thus deemed advisable to test each product first to find at which concentration a maximum kill was obtained.

By "maximum kill" is understood a percentage mortality round about 90-98. The cost to achieve 100% kill is shown to be unduly high since at 10 gallon per morgen of parathion (Folidol E.605) 95% mortality was obtained whilst at double the amount sprayed the mortality was 98%.

It has also been found that if the same amount of the active poison is used in concentrated form on a certain area the mortality drops, for example 10 gallons of Folidol E.605 and Dieseline and Naphthaline in the ration 50:40:10 respectively (23.3% parathion (Folidol)) gave a 95% kill.

Five gallons of the straight product (i.e. 46.6% Folidol) gave a 70% mortality. Technical parathion (98.3%) broken down to 25% with Ixlene and Dieseline gave a 60% mortality indicating a "lack" which is contained in other products.

Nocturnal Spraying Technique

Apparatus. Light aircraft (Super cub) fitted with sprayboom and 46 nozzles of the spraying system with D.12 orifice.

Spray pump pressure : 20 lbs/sq. inch.
Height of application : 20 feet above tree tops.
Aircraft speed : 80 miles per hour.
Swath width : 30 feet.
Deliverage : 5-10 gal/morgen (depending on viscosity).

Method. After receipt of information as to the presence of a swarm (nesting or roosting) a survey is made to estimate the size of the swarm (area occupied) by pacing off the perimeters. The boundaries of the colony having been established, poles 15-30' high are placed at intervals of 100 yards along 2 opposite sides of the area in line with each other. To the tops of these poles lighted hurricane lamps are attached in the late afternoon. These poles and lamps act as guides to the "swathers" as well as being a measuring device for the pilot of the aircraft to judge his spraying height.

Obstacles such as high trees etc. are further "lamped" to enable the pilot to locate them and keep clear whilst flying. It is often necessary to cut paths through the bush and/or to make tracks along which controllers' vehicles can move at night while checking on the swathing.

Spraying commences as soon as it is quite dark and the birds are well settled in their roosts. If spraying is done before it is dark there is a tendency for birds to move in great numbers out of the area to neighbouring bushes.

The "swathers", one at each of the roost and wearing full protective clothing and respirators, move along the lamped perimeters at predetermined distances each exhibiting a green light, on a tail pole, to the pilot to indicate to him his line of flight. The distance walked for each swath varies according to the dosage and viscosity of the chemical used. Correct spacing is maintained by having radio-equipped vehicles on each side of the colony following the swathers to keep them in contact with each other and with the aircraft, which is also fitted with radio. A third, radio-equipped vehicle is kept on the locally constructed airstrip to enable the pilot to obtain directions which will bring him back to the airstrip in the dark. This vehicle also provides lights to enable the pilot to land his aircraft safely.

Successive sorties are made until the entire area has been sprayed. As a guide a 50 acre colony takes up to 2½ hours to spray if the airstrip is not too distant.

This form of operation involves the use of the following personnel and equipment per operating unit:-

2 four wheel drive vehicles (radio-equipped).
1 three ton truck for chemicals (radio-equipped).
1 aircraft fitted with night flying instruments and electrical equipment.
2 European controllers.
1 pilot
5 labourers (1 driver acting as loading supervisor, 2 loading hands, 2 swathers).

Assessment of Mortality after Spraying

On the assumption that for every nest there are two adult birds, mortality is worked out on the following basis. Various trees are chosen at random throughout the sprayed area. The number of nests is counted by removal to make sure that they contain either eggs or young as well as to get the percentage of birds that died in the nest - which can be as high as 20% at times.

The first step is to count the number of dead females under each tree. This figure gives one a fair mortality guide. The reason for this is that the majority of male birds tend to roost together in suitable chosen clumps of bush giving erroneous counts which at times are 3-4 males to every female. Under scattered trees and on the edges of the colony one often finds more females than males. After the juveniles have left their nests there is a tendency for the females to join the males in "social spots".

A second step is to visit the area just before darkness sets in. A certain tree is chosen; the birds are scared out of it and counted as they fly out. The number of nests in that tree is noted and on this basis a percentage is worked out. This method holds up to the stage where the juveniles leave the nest. After the juveniles have left the nest mortality can be worked out by recording survival figures of juveniles per nest on the average of 3 juveniles per nest.

The above mentioned methods are very relative but have proved very close on checking a colony after a few days and counting the survived young if still in the nest, which means that they are still being fed by at least one parent. If either male or female parent succumbs the other will keep on feeding the young but only rear approximately half of the original young.

If counts are done ranging over the entire colony and if a great many samples are taken (at least a thousand individuals must be counted) the sex ratio in a normal breeding colony is very close to one male to every female with the males slightly in the majority. It was found that in the early stages of nest-building and egg-laying the males did exceed the females by as much as 3 males to one female. The reason may only be found out after the scores of colonies have been analysed. The total population mortality of adults can be assessed by doubling the nest figures and if the juveniles have left the nest by multiplying the nest figure by five (3 juveniles per nest is average).

Safety Precautions

Great care has been taken by the Ministry of Agriculture to give wide publicity to the hazardous nature of parathion to man and to livestock. Landowners are warned to keep their stock out of treated areas for a specified safety period and loading sites and sprayed areas are secured against entry of livestock. The public are given adequate advanced details of the specific sites to be sprayed and are warned against handling or eating dead or moribund birds in or near the general vicinity of a sprayed area. Unnecessary entry into a sprayed area is discouraged. Spraying is not carried out near dwellings, stock kraals, edible crops or open water of any kind.

For those engaged in spraying operations, cholinesterase tests are held at least once every three weeks. Antidotes are constantly available, also washing facilities and changes of clothing. The pilot's cockpit is made secure against penetration of spray and protective clothing is worn by all persons who are handling the material. The spray tanks on the aircraft are changed mechanically.

Use of Poisoned Baits

Parathion is also being provided by the Ministry of Agriculture without charge for farmers to use in poison baits based on grain. The chemical was only recommended for this purpose after thorough research. It must be generally regarded as less dangerous than chemicals which have been used locally for more than thirty years for this specific purpose (e.g. strychnine). Again the basic consideration is that parathion disperses fairly rapidly, while strychnine remains almost indestructible. Added to this is the further consideration that the birds are affected by parathion so rapidly that they eat very little of the poison and the bodies of sick or dead birds (should anyone eat them) thus contain much less poison than in the case of strychnine. Even in the case of strychnine the poisonous content of the carcases of the finches is so low that here it is not regarded as a danger.

Parathion has the additional advantage that although the effect on the human body is accumulative with repeated intake or contact, the poison itself does not accumulate in the body as do for example strychnine or arsenic. In cases of slight poisoning the affected person recovers on his own simply by withdrawing from further exposure, or atropine can be administered effectively if needed. In the Union directions to this effect, as well as full warnings, are in accordance with regulations supplied with each consignment of parathion preparation.

57/16 CONTRIBUTION TO THE CONTROL OF THE MEDITERRANEAN FRUIT FLY (CERATITIS CAPITATA, WEID.) ON ORANGES WITH DIELDRIN AND POISONED BAIT SPRAYS

G.P. GEORGHIOU. Department of Agriculture Cyprus.
Tech. Bull. 1/56. May 1956.

Following the introduction of more strict regulations with regard to Mediterranean fruit fly infestations, the need was seen for more efficient insecticides and methods of application. Experiments were carried out in Cyprus in 1955 on shamuti orange groves to follow up recent interest in dieldrin cover sprays, and also poison bait sprays incorporating organo-phosphorus insecticides and protein hydrolysates.

Materials and Methods

Eight different groves were divided into large plots with replicates in different groves. The plots contained a variable number of trees and the degree of infestation was not uniform throughout the area. Some treated plots received a dieldrin cover spray and others a malathion bait spray.

Cover spray: 0.1% active ingredient of dieldrin + 0.05% spreading agent; applied by a high volume sprayer at 600 gals/acre.

Bait spray: 0.5% malathion in a 5% sugar solution, applied by knapsack sprayer at 5 gals/acre. The strength of malathion and sugar was doubled after the middle of November.

Fly traps: standard glass invaginated fly traps using Clensel as attractant.

Protein: a locally obtained, partially hydrolysed, Brewer's yeast.

Spray treatments began on September 27 and were concluded on October 14. The dieldrin spray was applied once or twice, and the malathion bait treatments were repeated as soon as the effect of the previous bait treatment had disappeared. Evaluation of results was based

(a) on fly population level before and after treatments (indicated by six fly traps per plot)

(b) on percentage of infested fruit at harvest in three groves.

Laboratory tests were made to investigate the activity of residual spray deposits at various intervals after application.

Preliminary field experiments with a partially hydrolysed protein material incorporated in the malathion-sugar bait investigated the attractiveness of such a bait to the flies.

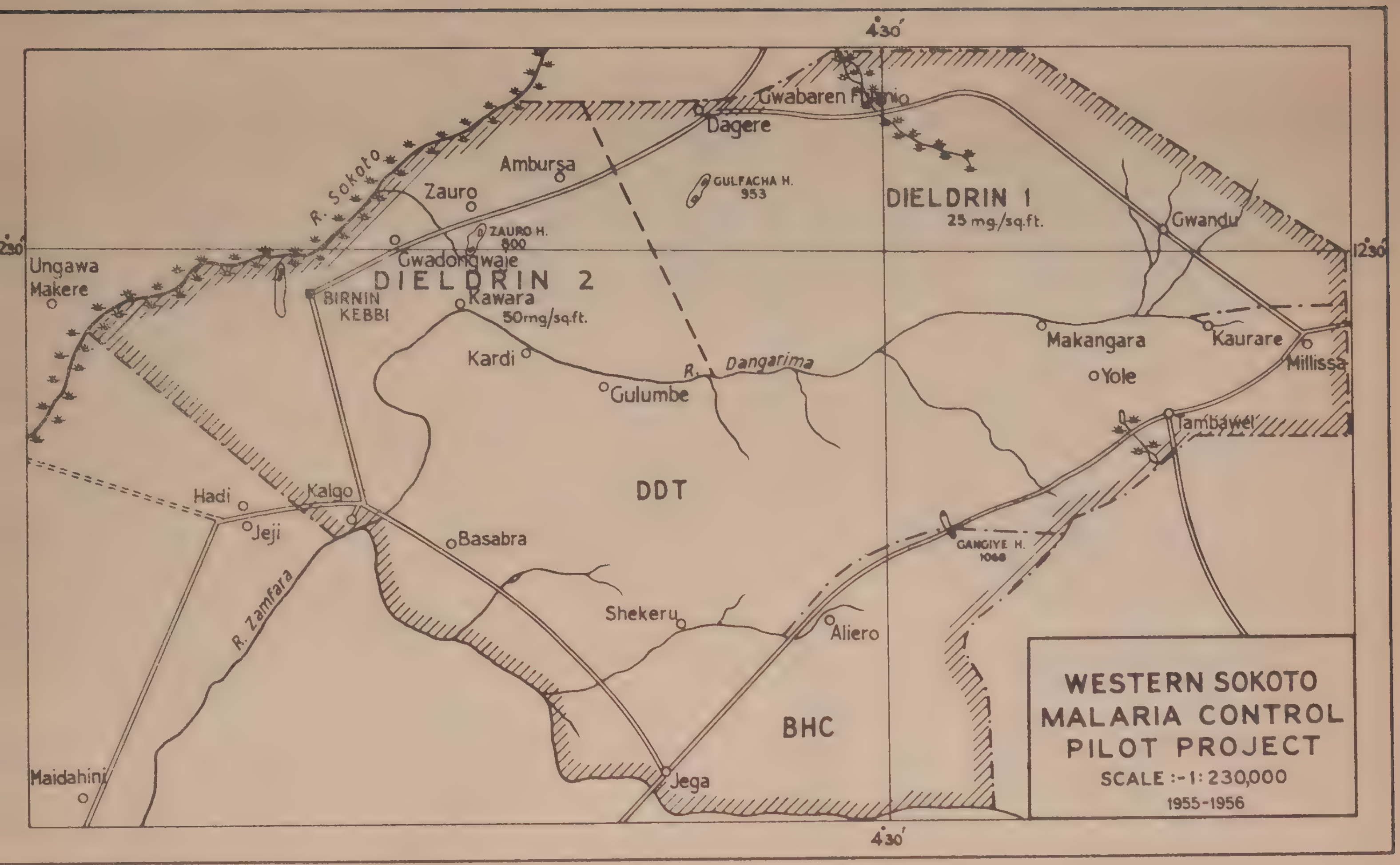
Summary of Results

Dieldrin. The first dieldrin spray in late September gave sharp reductions in population, which persisted for 32-40 days in heavily infested areas, or until harvest (60 days) in areas with small fly population. The percentage of infestation in fruit harvested from dieldrin treated trees in mid November was 0.38% (control 4.66%), and in February was 1.33 to 2.08% (control 16.91 and 18.05%).

Malathion. The fly population in the bait treated plots was reduced to a level several times below that of control plots, though the reduction was not consistent for all baitings. The effectiveness was greatly influenced by rain and high atmospheric humidity. Infestation of fruit in a plot treated four times was 8.94 (control 16.91%) and in a plot treated three times was 2.15% (control 4.04%)

Laboratory Experiments. Complete mortality of fruit fly within 24 hours was obtained after exposure to a 42 day old dieldrin deposit on orange leaves.

Protein. Results indicated that inclusion of protein hydrolysate in the bait spray increased the attractiveness of the bait almost five times.


WESTERN SOKOTO
MALARIA CONTROL
PILOT PROJECT
SCALE :- 1: 230,000
1955-1956
DIELDRIN 1
25 mg./sq.ft.
DIELDRIN 2
50mg/sq.ft.
DDT
BHC
4°30'
12°30'
R. Sokoto
R. Zamfara
R. Dangarima
GULFACHA H.
953
ZAURO H.
800
GANGIYE H.
1068
Gwabaren Fulani
Dagere
Ambursa
Zauro
Gwadongwaje
Birnin Kebbi
Kawara
Kardi
Gulumbe
Ungawa Makere
Hadi
Kalgo
Jeji
Basabra
Shekeru
Aliero
Jega
Maidahini
Gwandu
Makangara
Kaurare
Millissa
Yole
Tambawel

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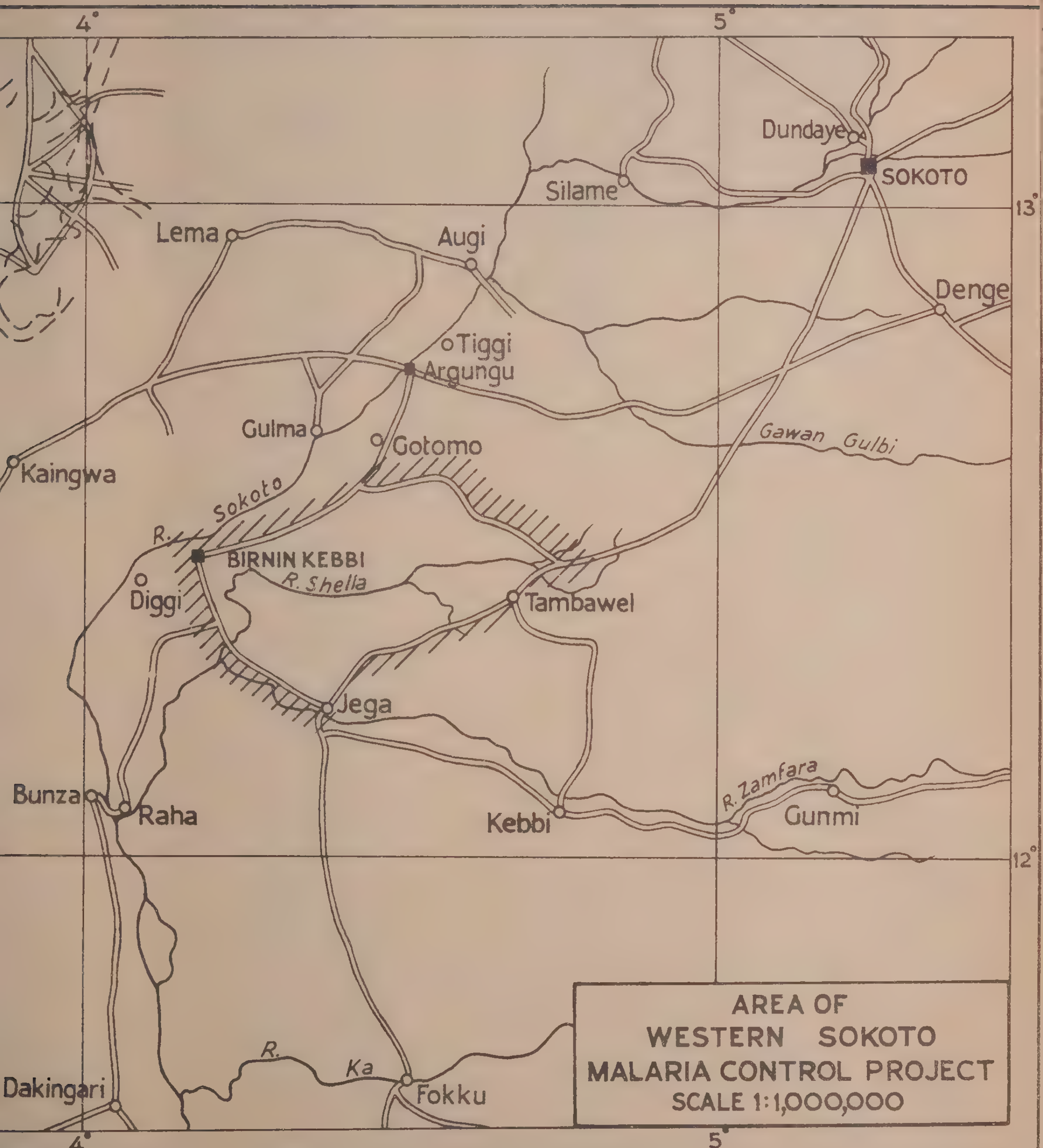
4°
5°
Dundaye
SOKOTO
Silame
13°
Lema
Augi
Denge
Tiggi
Argungu
Gulma
Gotomo
Gawan Gulbi
Kaingwa
R. Sokoto
BIRNIN KEBBI
R. Shella
Diggi
Tambawel
Jega
R. Zamfara
Bunza
Raha
Gunmi
Kebbi
12°
R. Ka
Dakingari
Fokku
4°
5°

AREA OF
WESTERN SOKOTO
MALARIA CONTROL PROJECT
SCALE 1:1,000,000

5/1/2475 820 1/57 CL

EDITORIAL

The second quarter of 1957 finds us with a steady increase in the volume of insecticides work to record. Apart from the usual unpublished reports, some of which are considered sufficiently important to have been copied almost verbatim by our abstractors, we have at last been able to include two of the type of review articles which we published in earlier numbers. These are: "Oils in Pesticidal Operations" by D. J. Colwill, and a summary of the additional information on surfactants which has accumulated since Mr. G. W. Wood's article of two years ago. We are grateful, as ever, to the manufacturers who have co-operated so willingly in helping to bring this information up to date.

NEWS ITEMS

(vii) CHEMICAL COMPOUNDS USED IN AGRICULTURE AND FOOD STORAGE IN GREAT BRITAIN. USER AND CONSUMER SAFETY. ADVICE OF GOVERNMENT DEPARTMENTS.

Recommendations are contained in a useful dossier issued by the Ministry of Agriculture, Fisheries and Food for the protection of operators and consumers against the following chemicals:

Aldrin
Chlorobenzilate
Dieldrin
Dieldrin SP
Dipterex SP
Malathion
Maleic Hydrazide
Monuron (CMU)
Schradan

Note- "SP" indicates stored products use. Otherwise recommendations relate to agricultural and horticultural use.

Precautions to be observed in handling formulations of the chemicals are among the conditions noted and, in relevant cases, dosage rates and minimum intervals between crop treatment and harvesting are given.

Data is based on the report of the Advisory Committee on Poisonous Substances used in Agriculture and Food Storage. The Committee numbers representatives from:

Ministry of Agriculture, Fisheries and Food,
Department of Agriculture for Scotland,
Department of Health for Scotland,
Agricultural Research Council,
Medical Research Council,
Government Chemist's Department,
Ministry of Health,
Board of Trade,
Nature Conservancy.

The Committee, assisted by a Scientific Sub-committee, will keep recommendations under constant review and revisions or additions will be issued from time to time.

Other publications of relevant interest include:

1. Leaflet APS/1 available free from Leaflet Room of M.A.F.F., 23, Soho Square, London, W.1.

2. Statutory Instruments 1956 No. 445. The Agriculture (Poisonous Substances) Regulations. H.M.S.O. Price 6d.

(viii) CHEMICALS AND MACHINERY FOR CROP PROTECTION

Fisons Pest Control Ltd. have issued a handy reference Catalogue to their main chemical products and spraying machinery, Products are itemised alphabetically under key groups such as insecticides, fungicides, herbicides, seed dressings, etc. Crisp notes indicating active constituent, concentration, properties and uses are written against each entry. Fuller details including toxicological data, in the form of technical bulletins, data sheets and related literature, are obtainable on request from the manufacturer.

The section on spraying machinery takes account of their tractor mounted and trailer applicators (Weedmaster 30, Weedmaster 60, Weedmaster Spray Rig, Fieldmaster M, Fieldmaster 150, Hopmaster, Universal Major) and reference is made to the new comprehensive range of hand spraying equipment, including a variety of knapsack sprayers being manufactured on their behalf by W. T. French & Sons Ltd.

A final section is devoted to Du Pont herbicides and fungicides which Fisons are marketing by arrangement with the American Company.

The following insecticidal products are listed:

Insecticides

Aldrin 30% w/v miscible oil (Toxadrin)
Dieldrin 15% w/v miscible oil (Supadiel)
Hanane 50 (50% w/w dimefox)
Malatox (50% w/v malathion miscible oil)
Paraphos 40 (40% w/v parathion)
Pestox 3 (55% w/v schradan (OMPA))
Psylortox 250 (25% w/v DDT)
S.14 (20% w/v dimefox)
Schradan Technical (OMPA) (68-80% w/w OMPA with approx. 15% related compounds; unformulated).
Tabb Concentrate 370 (37% w/v dinoseb (DNBP) alkanolamine salt, winter wash)
Tabb 38 (18.5% w/v dinoseb (DNBP) alkanolamine salt winter wash)

Acaricides

Tedion V-18 (20% mixture of highly chlorinated diphenyl sulphones; wettable powder).

Seed Dressings

Seedox (Organo-mercurial compounds equivalent to 1.25% w/w mercury and dieldrin; powder for dry application)

Fumigants

Nematox 85 (85% w/w ethylene dibromide in an inert solvent)
Nematox 95 (95% w/w ethylene dibromide in an inert solvent)
Nematox 100 (100% ethylene dibromide)

(ix) CYCLIC KETONE SOLVENTS

Howards of Ilford Ltd. have produced a brochure describing the properties and applications of their cyclic ketones registered under the trade names Sextone (cyclohexanone), Sextone B (methylcyclohexanone) and Sextone Z (dimethylcyclohexanone).

The Sextones are strong solvents for DDT and other pesticides. Sextone and Sextone B will dissolve approximately their own weight of DDT and they are also excellent solvents for benzene hexachloride and for pentachlorophenol. The solvents are stated to be non-phytotoxic when used at normal operating concentrations, e.g. 0.5-5.0%. The Sextones are miscible with the usual solvents: alcohols, esters, ethers, ketones, hydrocarbons (aliphatic, aromatic and chlorinated), etc. They are not inflammable, explosive, toxic nor corrosive. They are readily volatile in steam and do not absorb water. They are considered to be harmless and have been used in large quantities over a period of many years in industry without ill effect. They may, however, cause slight irritation to the mucous membranes of particularly sensitive individuals. Prolonged exposure to very high concentrations of the vapour should be avoided.

The following properties are listed:

	Sextone	Sextone B	Sextone Z
Appearance	A colourless liquid	A colourless liquid	A colourless liquid
Odour	Ketonic	Ketonic	Ketonic
Boiling range $^{\circ}$C at 760 mm 95 per cent	150-158	160-175	179-195
Vapour pressure at 100°C mm Hg	123	93	65
Vapour pressure at 20°C mm Hg	2.45	0.62	0.25
Specific gravity at 15.5°/15.5°C	0.950	0.925	0.912
Gallons per ton	236	242	246
Ketone content min per cent	88	88	88
Flash point Abel closed test $^{\circ}$F	107	117	142
Viscosity at 25°C centipoises	2.24	1.78	1.85
Refractive index n_D^{20}	1.452	1.448	1.449
Evaporation period (ether = 1)	40	47	100
Solubility in water at 20°C per cent	5	3	3
Solubility of water in, at 20°C per cent	7	3	3
Specific heat at 20°-30°C cal/gm av	0.443	0.460	0.467
Melting point $^{\circ}$C	— 32	- 76	-
Azeotrope with water, boiling point $^{\circ}$C at 760 mm	96.5	97.5	97.5
Azeotrope with water, per cent water	60	60	65

(x) ENDRIN - THE FOLIAGE INSECTICIDE

An attractive brochure by Shell on endrin completes a formidable insecticide trio: aldrin, the soil insecticide, dieldrin in public health and endrin for foliage.

Since endrin was first synthesised about six years ago it has been shown effective for controlling a wide variety of economic pests. It is stated that for most purposes, successful insect control can be obtained with endrin at 0.1-0.5 lb active material per acre. Its applicability to such important crops as coffee, cacao, cotton, forest trees and wattle, maize, sugar cane, orchard fruit, rice, tobacco, turf and pasture and others is outlined in this publication.

Careful emphasis has been placed on the safety measures to be observed in view of its high mammalian toxicity rating. The recommendations set out enable the full benefit of treatment to be obtained in spite of the attendant hazard.

Endrin is described as a contact and stomach poison possessing a prolonged residual effect of 10-20 days on foliage. Chemically it is a chlorinated hydrocarbon derivative described as

1,2,3,4,10,10-hexachloro-6, 7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1, 4-endo-endo-5, 8-dimethanonaphthalene. It is claimed to be non tainting and without risk of damage to plants. The material is supplied in the form of technical endrin (more than 90% pure compound) high concentrate dusts, emulsifiable concentrates for dilution with water to form aqueous sprays, "or ready to use" field strength dusts.

The brochure is indexed and contains a handy conversion table. The following properties of technical endrin are listed:

Property	Description
Physical State	Solid, powdery, crystals
Colour	Light tan
Odour	Mild chemical
Insoluble residue, % w	Less than 0.5 in xylene
Density, lb/I.G. at 68°F	17.5
Vapour pressure, mm Hg at 77°F	2 x 10-7
Setting point	Rearranges when heated above 392°F
Bulk density, lb/cu ft	55 to 60
Endrin content, % w, minimum	90
Water content, % w	Less than 0.1
Free acid, % w	Less than 0.4, calculated as acetic acid
Solubility at 77°F, in saturated solution, % w (approximate)	
Acetone	28
Benzene	37
Carbon Tetrachloride	24
Diesel Oil	11
Isopropyl Alcohol	4
Kerosene	6
Methyl Ethyl Ketone	33
Trichlorethylene	41
Xylene	39
Water	Less than 0.1 ppm
Stability in Storage	Excellent

(xi) FORMULATION OF PYRETHRUM INSECTICIDES

A comprehensive manual of pyrethrum data is available from Mitchell Cotts & Co. Ltd. Though primarily intended for the guidance of prospective formulators it is deserving of careful investigation by others.

Between notes relating to the history and general properties of pyrethrum and a glossary of the pests controlled there is a copious digest on pyrethrum compositions selected for a variety of purposes - fly sprays, cockroach sprays; formulations for crop protection, for the protection of stored products and of livestock; formulations for use in aircraft, ships, and places where food is stored or handled. There is also a useful section describing several pyrethrum synergists.

It is evident that pyrethrum will continue to serve a valuable function in pest control whether it be on account of its completely non toxic mammalian character, its stimulatory effect in conjunction with the synthetics, its knock-down activity, or its ability not to promote resistant strains.

xii) SUMMARY OF RECENT AERIAL WORK

R. F. HILL, Colonial Pesticides Research Unit, Porton. (Reference PPR 7).

Auster J5G Aircraft XJ941

In aerial spraying trials using Diethyl Phthalate as the test liquid it was observed that DEP had an adverse effect on the rubber of the bonded seals between the jet holders and the boom, many of them becoming completely unserviceable. In addition the main feed and return hoses began to show signs of rapid deterioration and sludge formed by interaction of liquid and dye gave considerable trouble from the maintenance angle.

Percival Aircraft Co. Ltd.

The Percival Aircraft Co. are in consultation with C.P.R.U. on the design of a boom and nozzle spray system for installation on their new EP9 aircraft which has been produced for agricultural uses.

Rotary Atomiser (Messrs. Britten-Norman)

It is considered that modifications will have to be carried out on the apparatus at Porton before it can be regarded as suitable for use under East African conditions.

(xiii) RECENT PROMOTIONS, TRANSFERS AND APPOINTMENTS

The following list compiled from information supplied by the Colonial Office, includes only the officers whose duties will be concerned with entomology, pest control and related fields.

January 1957

Miller, H. C., Chairman of the Yallahs Valley Land Authority, Jamaica	Director of Agriculture, Jamaica
Stuart, W. G., Chief Agricultural Officer, Jamaica	Deputy Director of Agriculture, (Research), Jamaica
Browning, A. J., Senior Assistant Conservator of Forests, Sierra Leone	Senior Assistant Conservator of Forests, Cyprus
Burra, J. A. N., Assistant Conservator of Forests, Cyprus	Conservator of Forests, Jamaica
Seward, J. L. A., Principal Forester, Northern Rhodesia	Assistant Conservator of Forests, Northern Rhodesia
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57/17 AIRCRAFT APPLICATIONS OF INSECTICIDES IN EAST AFRICA. DROPLET DISTRIBUTIONS FROM FLAT-SPRAY NOZZLES.

D. YEO, Colonial Pesticides Research Unit, Arusha.
Misc. Rep. No. 160 November 1956.

When an insecticide is used in a liquid formulation to control an insect pest, the droplet sizes are often very important. An unsuitable choice of drop spectrum can lead to an inefficient use of the insecticide, and can alone be the cause of inadequate control. It is of practical value, therefore, to be able to predict the droplet distributions that can be obtained from a particular spraying installation.

During recent years many assessments have been made at Arusha of the performance of boom-and-nozzle systems fitted to aircraft. The assessments have usually been part of the routine work of the unit, so that a wide variety of nozzles, liquids, and types of aircraft and installations, have been tested, often in single unrelated experiments. During 1955 and 1956, however, some systematic work was done, although a comprehensive series of tests was not possible because there were only limited periods during which the aircraft were available. Using flat-spray nozzles a somewhat crude but nevertheless useful relation has been found between the droplet distribution, as represented by the Sauter Mean Diameter, the physical constants of the liquid, the volume and velocity of emission of liquid from the nozzle, the velocity of the aircraft, and the orientation of the nozzles relative to the direction of flight of the aircraft. Most of the experiments were done with ceramic Bray nozzles, which had rectangular orifices and produced flat sprays, and it is with these nozzles that this report is mainly concerned.

The Measurement of Droplet Sizes and the Analysis of the Droplet Distribution

Conventional methods, described elsewhere (Yeo, 1955), were used to determine the numbers and diameters of the droplets. The aircraft was flown at a suitable height, and the ground deposit was estimated in such a way that no undue importance was given to any particular sample. Earlier work, confirmed by Jarman (1956), had shown that adequate measurements of the droplet distribution, although not always of the ground recovery, were possible with a very limited number of rows of samples.

Since the main aim of most of the experiments was the determination of droplet distribution, two rows of samples were laid out in most cases, and on occasions, when time was very limited, this was reduced to only one row. Errors were somewhat increased by using this reduced number of samples, but it was possible to carry out more experiments and to cover more experimental arrangements in this fashion than if more extensive sampling had been attempted.

Two types of samples were taken. Deposits were collected upon glass plates coated with Magnesium oxide, and the droplet distributions and ground recoveries of volume were calculated from microscopical counts of the craters produced by the droplets (May 1945, 1950); on a few occasions a comparable technique, using absorbent papers, was used when the droplets were relatively large. To avoid the possibility that the craters in the oxide would deteriorate with time, and that quality might be adversely affected, the deposits of oxide were never more than 36 hours old at the time of the experiments, and the size counts were done as soon as possible, usually within 12 hours and only rarely later than 48 hours after the deposits had been formed.

In addition to these oxide-coated plates or absorbent papers, each sampling point included either a clean plate or a paper, the deposits upon which were extracted with a suitable solvent and estimated colorimetrically; when necessary a fast dye was added to the solution to facilitate this colorimetric work and the microscopical counting. The second group of samples was used to check the accuracy of the size counts in the case of an involatile liquid, and with volatile liquids the recoveries from the two types of samples could be used to estimate the extent of solvent losses by evaporation that occurred before the droplets were deposited.

Oxide-coated plates are not ideal for large droplets, for which they over-estimate the diameters and lead to a too high value for the volume recovery. Such errors occurred in this work, as may be seen from Table 1, where recoveries from the oxide-coated plates are compared with the colorimetric recoveries, using a solution for which no appreciable evaporation losses of solvent were likely. The size counts gave too high recoveries for droplet distributions having Volume Median Diameters greater than 200 microns, but the two methods of assessment gave gratifyingly consistent results for smaller droplets. This error in sizing was minimised to some extent by the choice of the parameter to specify the droplet distribution.

Several parameters are in use to describe a given droplet distribution. Probably the soundest and most widely used is the Sauter Mean Diameter, which is defined by the equation

$$D_o = \frac{\Sigma\Delta n.\ x^3}{\Sigma\Delta n.\ x^2} \quad \dots\dots\dots (1)$$

where D_o is the Sauter Mean Diameter, and Δn is the number of droplets of diameter x. For a continuous distribution the summations are replaced by integrals. This parameter gives the diameter of a droplet having the same ratio of surface area to volume as the entire spectrum, and is a reasonable choice to define a physical process where kinetic energy is to a considerable extent transformed into surface energy. Its value is most affected by the intermediate droplet sizes, and its use therefore minimises the effect of inaccurate measurements at both ends of the spectrum.

Many attempts have been made to fit droplet distributions with empirical mathematical formulae. One such equation, introduced by Tanasawa and Nukiyama (1939), is of the form

$$dn = a\, x^p.\ e^{x^q}.\ dx \quad \dots\dots\dots (2)$$

where x = droplet diameter,

dn = the number of droplets having diameters in the range $x - \frac{1}{2}dx$ and $x + \frac{1}{2}dx$,

and a, b, p, and q are constants for a given distribution. It appears that generally $p = 2$, and the Japanese and other workers (Kruse et al, 1949, Dorman and Narracott, 1950) have re-written equation (2) in the form

$$\log_{10}\left[\frac{1}{x^2}\ \frac{dn}{dx}\right] = \log_{10} a - \frac{bx^q}{2.30} \quad (3)$$

and have obtained the values of a and b by a graphical method in which the value of q is varied until a linear plot of equation (3) is obtained. The Sauter Mean Diameter is a function of b that depends upon the value of q; some important practical cases are given in Table 2, which also records the ratios of the Volume Median Diameter D_v to the Sauter Mean Diameter D_o. It is noteworthy that D_o is less than D_v.

This method of analysis is an attractive one because it involves relatively little arithmetical labour, and an attempt was made to use it. It was found that a good fit was nearly always obtained with $q = \frac{1}{2}$. Many calculations showed that D_o was larger than would have been expected from Table 2, and in some cases it was larger than D_v, a result at complete variance with the theory. Equation (3) seemed not to be wholly applicable, therefore, and D_o was finally calculated more laboriously from equation (1).

For most experiments evaporation losses of solvent were not high and did not greatly affect the droplet distribution. In a few cases, however, as much as 50 per cent of the solvent was lost by evaporation before the droplets were deposited, and some account of this loss had to be made before the true value of D_o could be calculated. In most of these cases a solution was used for which previous work (Yeo and Thompson, 1954) had shown that evaporation losses were approximately constant for all droplet sizes, and it was therefore reasonable to assume that the true value of D_o could be obtained by multiplying the measured value by the ratio

$$\left(\frac{\text{Colorimetric recovery}}{\text{Volume recovery}}\right)^{\frac{1}{3}}$$

In the other few cases there was no detailed knowledge of evaporation losses, but it was assumed that the same correction could be applied.

A Dimensional Analysis of the Process of Droplet Production

It seems improbable that a complete physical and mathematical description can be given of the process of droplet production as a liquid is emitted from a nozzle, but some progress is possible by using the methods of dimensional analysis.

It is reasonable to assume that the droplet sizes would probably be affected by the following factors:

Q = the volume of liquid emitted in unit time
S = the surface tension of the liquid
ρ = the density of the liquid
μ = the viscosity of the liquid
V = a velocity, which in some way includes the velocity of emission from the nozzle, and also takes account of the velocity of the liquid relative to the stationary air.

It should be noted that the dimensional analysis cannot include dimensionless factors that might be important. For example, the spray angle can be and almost certainly is important and should probably be included in the terms containing Q, but this cannot be deduced from the dimensional analysis.

If D_o can be considered as an adequate parameter for describing the droplet distribution, then it is possible to write

$$D_o = Q^j S^k \rho^m \mu^n V^p \qquad \text{.........} (4)$$

where j, k, m, n, and p, are undetermined exponents. Dimensionally this equation may be written

$$\left[L\right] = \left[L^3 T^{-1}\right]^j \left[MT^{-2}\right]^k \left[ML^{-3}\right]^m \left[ML^{-1}T^{-1}\right]^n \left[LT^{-1}\right]^p$$

and so

$$\begin{aligned} 1 &= 3j - 3m - n + p \\ 0 &= k + m + n \qquad \text{.........} (5) \\ 0 &= j + 2k + n + p \end{aligned}$$

These three equations cannot be solved completely, but it is possible to express all components in terms of any two of them. When this is done equation (4) may be re-written in several forms, a typical one being

$$\left[\frac{D}{\left(\frac{Q\mu}{S}\right)^{\frac{1}{2}}}\right] = \left[\frac{Q\rho^2 V^3}{S^2}\right]^c \phi \left[\frac{S}{\mu V}\right] \qquad \text{.........} (6)$$

where c is some undetermined exponent, and ϕ denotes some function of $S/\mu V$ that must be found experimentally.

Equation (6) gives the general form of the relationship between the various factors. Its form can be varied considerably; the only criterion is that each term within the brackets must be dimensionless, and the analysis is in fact a special case of a general method described by Buckingham (1921). It must be remembered that its applicability depends entirely upon the validity of the assumptions embodied in equation (4), and, as was mentioned previously, it does not preclude the possibility that dimensionless factors can affect D_O, perhaps overridingly so. Indeed, as will be shown later, one such dimensionless factor, a ratio of two velocities, was found to be of considerable importance.

The rather unconnected data were not complete enough to investigate equation (6) systematically. An examination of other work, summarised by Fraser (1956), suggested that viscosity would not be very important, but also suggested that the dimensional analysis would lead to an incomplete understanding of the problem and that an accurate picture would only be possible by making measurements of factors other than those included in equation (6). On the other hand, Dorman and Narracott (1950), working with stationery nozzles but otherwise with very similar conditions to those of the experiments described in this report, obtained good correlations using the dimensional approach, taking into account the spray angle.

Using a single solution, groups of data were collected for various nozzles operated at a constant pressure and a constant orientation of the nozzle relative to the direction of flight of the aircraft.

The relation between D_O and Q is indicated by the equation

$$D_o \propto Q^{\frac{1}{3}} \qquad \text{.......................(7)}$$

and this, combined with the omission of viscosity from the dimensional analysis, allows equation (6) to be much simplified to

$$D_o \propto \left[\frac{Q\,S}{\rho}\right]^{\frac{1}{3}} \times \left[\frac{1}{V}\right] \qquad \text{.......................(8)}$$

which is identical in form to that used by Dorman and Narracott (1950).

The value of V

It is not immediately obvious what value to assign to V. For a stationary nozzle the emission of liquid can be represented by the equations

$$Q = C_Q A \sqrt{\frac{2P}{\rho}} = C_A C_V A \sqrt{\frac{2P}{\rho}} \qquad \text{..........(9)}$$

where P = the pressure head at the orifice
A = the cross-sectional area of the orifice
C_Q, C_A, and C_V are respectively the coefficients of discharge, area, and velocity, and the other symbols have the same meaning as before.

In a perfect nozzle the coefficients would be unity, but in practice this is usually not so; furthermore, whereas it is a simple matter to measure C_Q, it is difficult to measure separately the values of C_A and C_V, with the result that the effective velocity

$$v = C_V \sqrt{\frac{2P}{\rho}} \qquad \text{..........(10)}$$

is not known with great accuracy.

Fortunately, for the Bray nozzles the coefficient of discharge was not very much less than unity, and no greater error was likely to be introduced by assuming that $C_Q = C_A$. Straus (1949) assumed that $C_Q = C_V$; in the work described in this report the assumption that a loss of area occurred, rather than a loss of velocity, gave a slightly smaller scatter in the results.

For stationery nozzles this effective velocity would reasonably be substituted into equation (8). For moving nozzles it seemed likely that the magnitude of the resultant velocity V_o of the velocity emission of liquid from the nozzle and the velocity of the aircraft, i.e. a crude measure of the velocity of the liquid relative to the stationery air, would also be important, and that a unique relationship would be obtained of the form

$$\frac{D_o v}{\left[\frac{Q\ S}{\rho}\right]^{\frac{1}{3}}} = \chi\left[\frac{v}{V_o}\right] \qquad \text{.................... (11)}$$

where χ denotes some function of $\frac{v}{V_o}$. It was in this form that the data were examined.

Results

On plotting the data according to (11) it is found that the postulated relationship fits quite well and with one or two exceptions the points are within 10 per cent or so of the mean graph; errors of this sort would have been expected from the experimental procedure. For large values of $\frac{v}{V_o}$ the effect of this factor becomes of minor importance, and v, the velocity at which the liquid leaves the nozzle, becomes the relevant velocity. For $\frac{v}{V_o} = 1$ the Sauter Mean Diameter is given by

$$D_o = 4.9 \left[\frac{Q.S}{\rho}\right]^{\frac{1}{3}} = \frac{1}{v}$$

which agrees well with the values given by Dorman and Narracott (1950) for stationery nozzles.

When the Bray nozzles pointed directly forward along the direction of flight of the aircraft, there was some suggestion that the variation of D_o with Q was less rapid than is given by equation (7), particularly when the pressure was as low as 20 p.s.i. On the other hand the average values from such groups of data lay very close to the mean line of the plot, so perhaps the effect was not a real one, but was caused by an unusual combination of errors. It seems possible, however, that with this orientation of the nozzles some liquid would be blown back upon the boom and the nozzle assembly, and if possible it would be good practice to arrange that such an effect could not occur.

There was also a suggestion that increasing the pressure beyond 100 p.s.i. or so did not reduce the value of D_o as much as might have been expected; this was deduced from the fact that the three experiments done at these relatively high pressures tended to lie above the mean line.

Discussion

In such work, where empirical fits are made to experimental data, it is generally unwise to extrapolate beyond the limits of variation of the various factors. These limits are therefore given in Table 3; a usefully wide range of conditions has been investigated as far as the nozzles and the pressures are concerned, and the relationship fits for quite viscous liquids. The variations in surface tension and density are slight, however, and the dependence upon them, as given by equation (11), arises from the dimensional analysis rather than from the experimental data. A dependence upon surface tension of this form has been suggested before, however, (see Fraser, 1956) and in practice variations in density are in any case slight, so that the relationship is probably of rather more general applicability in these two respects than might at first be expected from the range of values covered by the experiments.

It is likely that equation (11), and relationship based upon the considerations that led to it, would not apply to liquids of very high viscosity, and probably not to very low pressures. It is also most probable that different relationships would apply to much larger orifices, when the size of the orifice plays little or no part in determining the value of D_o.

In practice a limit is imposed upon the smallest size of orifice that can be used, the maximum aircraft velocity, and the maximum pressure. Very small orifices tend to block easily and for this reason are often impracticable for routine work, which very high pressures entail more elaborate equipment and greater precautions to guard against the possibility of mechanical and structural failure; while greatly increased flying speeds are usually only possible with much more expensive aircraft and add greatly to the already considerable risks attached to the low flying usually associated with insecticidal applications. There is, therefore, a lower limit to the value of D_o that can be obtained in practice, some estimate of which can be made from the following assumptions:

(i) Maximum aircraft speed = 100 m.p.h.
(ii) maximum pressure = 150 p.s.i.
(iii) surface tension = 25 dynes per cm.
(iv) density = 1.2 gm per cc.
(v) minimum orifice area = 0.008 sq. cm. equivalent approximately to a Bray 0 nozzle.

Using the plot of (11), a value of 70 microns is obtained as approximately the lower limit of D_o that can be obtained with these Bray nozzles. Smaller droplets would have to be produced by some other means, possibly by rotary atomisers, twin-fluid nozzles (which are sometimes called compressed-air nozzles), or by installations that use the exhaust gases from the aircraft engines to produce a thermally generated aerosol.

It is appreciated that the data have been analysed in a very crude fashion, and that many factors, notably the probable variation in spray angle and changes in shape of the liquid sheet under various conditions, have been ignored. This crudity of approach was largely the result of the unconnected way in which the experiments were carried out, and the unpredictable and short periods during which an aircraft was available. It is hoped that some of these shortcomings will be removed by later work, but the present investigation has proved to be well worthwhile in that it has, despite the omissions, given a very useful and reasonably accurate technique for predicting droplet distributions.

A previous attempt has been made (Kruse et al, 1949) to correlate droplet sizes produced by nozzles fitted to aircraft installations. These workers obtained, for stationery 'Teejet' nozzles (manufactured by Spraying Systems, Chicago, U.S.A.) the following relationship

$$D_o = 5,300 \left[\frac{\mu S}{\rho V}\right]^{1.06} \qquad \text{(12)}$$

and for nozzles fitted to aircraft the relationship

$$D_o = \frac{6000}{\dfrac{1.13}{\left[\dfrac{\mu S}{\rho V}\right]^{1.06}} \left[0.966 \left[\dfrac{V_o}{100}\right]^{0.2554}\right]} \qquad \text{(13)}$$

where V = Q/A and A is the cross-sectional area of the orifice.

Both these equations are open to criticism. Firstly, equation (12) postulates a dependence upon viscosity and surface tension that has not been found by other workers for this range of experimental conditions, but more important still it implies that no change in D_o occurs with changes in nozzle size but only with operating pressures, and this seems contrary to other work. Similar objections apply to equation (13), which has the added disadvantage of implying that

$$D \longrightarrow \infty \qquad \text{as} \qquad V_o \longrightarrow 0$$

which is most unlikely. This last objection would be removed by using an equation containing

$$\left[\frac{V_o}{v}\right]^{0.2554} \qquad \text{instead of} \qquad \left[\frac{V_o}{100}\right]^{0.2554}$$

and this would still be compatible with their data.

The data of Kruse et al has been plotted in the form of equation (11). The American data is similar in form to that with Bray nozzles but shows a less pronounced curvature on graphing.

TABLE 1

Some comparative figures for the colorimetric recoveries and the volume recoveries obtained from microscopical counts of craters upon oxide-coated plates.

Volume Median Diameter (microns)	Number of tests	Ratio $\frac{\text{Volume Recovery}}{\text{Colorimetric Recovery}}$
100-150	10	0.99
150-200	7	1.02
> 200	6	1.38

TABLE 2

The relation between D_o and b, and between D_o and D_v, for various values of q.

q	D_o	D_v/D_o
2	$1.5/b^{\frac{1}{2}}$	1.10
1	$5/b$	1.14
$\frac{1}{2}$	$110/b^2$	1.23
$\frac{1}{3}$	$4080/b^3$	1.35
$\frac{1}{4}$	$213000/b^4$	1.47
$\frac{1}{5}$	$14300000/b^5$	1.60

TABLE 3

Limits of the various factors.

Factor	Minimum value	Maximum value
Q	8 cc/sec	80 cc/sec
S	29 dyne/cm	37 dyne/cm
ρ	0.86 gm/cc	1.02 gm/cc
μ	0.028 poise	0.12 poise
P	20 p.s.i.	100 - 130 p.s.i.
A	0.006 sq. cm.	0.025 sq. cm.
Aircraft speeds	65 m.p.h.	120 m.p.h.

57/18 SOME TESTS WITH THE BOOM-AND-NOZZLE INSTALLATION FITTED TO THE D.H. BEAVER AIRCRAFT VP - KNH

D. YEO and H. H. COUTTS. Colonial Pesticides Research Unit, Arusha. Misc.Rep. No.170. Dec.1956.

Description of the Installation

The installation is generally a good example of a boom-and-nozzle system. A large storage tank is fitted into the fuselage behind the pilot's seat; it is lined with a neoprene bag, which, although perhaps ideal for certain jobs, tends to disintegrate under the action of the solutions used for locust control. From the tank the liquid flows to a windmill-driven centrifugal pump, fitted beneath the fuselage near the under-carriage; it is then pumped into the boom and emitted through nozzles fitted with the diaphragm type of check valve. The boom has an aerofoil section and extends for the entire wing span of the aircraft.

Two coupled gate valves, operated from the cockpit and acting in opposition, enable the emission rate to be altered by varying the sizes of the apertures leading to the boom and to the pipe that by-passes liquid back to the storage tank. This adjustment is possible during flight. There is also an electrically operated dump valve for use in cases of emergency.

Emission Tests

The maximum possible emission rates of the windmill-driven centrifugal pump were measured. High emission rates were selected in view of recent field work against locusts (Macdonald, unpublished) indicating that such rates may be necessary under certain circumstances. From the results obtained, using water as the test fluid, it is evident that a considerable drop in emission rate occurs as the operating pressure rises. It was not possible to achieve pressures above 100 p.s.i.

An expression for converting emission rates found for water to values for other liquids is given by

$$\text{Emission rate} \propto \sqrt{\frac{1}{d}}$$

when d = density of the fluid.

The Determination of Droplet Distributions

The droplet distributions were determined by conventional methods (see Yeo, 1955). "Whirljet" nozzles, manufactured by Spraying Systems, Chicago, U.S.A., were used in the tests. Two sizes were available, with orifice diameters of 3/32 inches (No. 3 nozzle) and 1/8 inches (No. 5 nozzle) respectively. The nozzles and the check valves were fitted to the boom with short drop legs, and their orientation was such that the axial line of emission was either forwards and downwards at an angle of 45° to the horizontal, or backwards and downwards at the same angle.

Droplet distributions were determined for various pressures at these two nozzle orientations. The distribution of volume among the droplets was calculated by the usual method (see Yeo, 1955), yielding the Volume Median Diameter D_V. while the Sauter Mean Diameter D_O was calculated from the equation.

$$D_O = \frac{\Sigma \Delta n x^3}{\Sigma \Delta n x^2}$$

where Δn was the number of droplets of diameter x.

The writers conclude that high emission rates are only possible at relatively low operating pressures and with relatively coarse droplet distribution. To obtain finer spectra it would be necessary to use high pressures and finer nozzles. At high emission rates this would entail a greater number of nozzles and a pumping unit of greater capacity at these higher pressures.

A typical droplet distribution is given, also an endeavour is made to rationalise the data. The information thus obtained can be used to predict Sauter Mean Diameters for the two nozzle orientations and various operating pressures, within the limits of variation of the various factors and for an airspeed of 90-95 m.p.h.

57/19 THE USE OF GLOSSY PAPER FOR THE DETERMINATION OF DROPLET SIZES

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During a visit to the U.S.A. it was noticed that glossy paper was being used to determine droplet sizes. Although the stains produced upon such paper are somewhat smaller that upon filter paper; they are more clearly defined because the grain of the paper is less, and smaller droplets can be sized. Working upon the principle that an extra tool is useful, a search was made for a suitable paper of British manufacture; the search was by no means exhaustive, and was stopped when a suitable paper had been found.

A glossy "art" type of paper has to be used if well defined stains are to be produced, and the best results were obtained with the following sample:-

> Invercarron Art Paper-Reference 2108 (White Art 2/s Weight 50), manufactured by
>
> The Carrongrove Paper Co. Ltd.,
> Denny, Scotland.

Method of Calibration

For much of the range covered by the calibration, the Porton Microburette was used to produce droplets of calculable size, and these were allowed to fall upon the glossy paper. No laboratory apparatus was available for producing droplets smaller than about 150-200 microns, and for these smaller sizes the relation between stain diameters and droplet diameters was deduced from comparisons of the distribution of stain sizes upon the paper with the distribution of crater sizes upon oxide-coated plates.

Two liquids were investigated: water containing 0.75 per cent w/v of Croceine Scarlet dye: and neat Acrodel, a very viscous involatile solution of γ BHC in oils, to which 0.9 per cent w/v of Waxoline Red dye was added. The comparison of the distributions of stain sizes and of crater sizes is somewhat suspect for water because water droplets tend to bounce off the oxide - coated plates but nevertheless the results give what is believed to be a sufficiently accurate extension of the work with the microburette; no such doubts arose with the results for Acrodel.

Results

The stains were allowed a few hours to stabilise, and measurements were then taken. During a period of a week repeated measurements were made and there were no detectable changes in the stain sizes. For the smallest droplets the stains were rather faint and were measured most comfortably using transmitted light.

The stain diameter bore a constant relationship to the droplet size over a period of a week or so, according to the following equation.

Water $$D = 0.318\,(S)^{1.065} \qquad \text{..........(1)}$$

Acrodel $$D = 0.722\,(S)^{0.836} \qquad \text{..........(2)}$$

where D = Droplet diameter and

S = Stain diameter, both in microns.

The relationship for Acrodel shows the same power relationship between D and S as was found by Jarman (1956) for filter papers; a different power law applied to the water solution, however.

Ref. Jarman, R. T. (1956). Quart.J.R.Met.Soc., 82, 352.

57/20 BILHARZIASIS IN EAST AFRICA

W. F. McCLELLAND. Extract from East African Medical Survey and Research Institute Annual Report 1955-1956.

For the benefit of any non-medical readers of this report who may be interested, a few general points about this condition may be recapitulated. The disease is caused by a species of fluke (schistosoma), creatures of worm-like appearance, allied to the liver-flukes of domestic animals, the adult forms of which live in the veins of the portal system, near the large intestine and the bladder. There is a very large number of species of schistosomes, and domestic and wild animals, birds and amphibians are infected as well as man. The species infecting animals, in general do not infect man. The adult worm, which are one to two centimetres long, pair in the veins where the females lay eggs. The eggs work their way out of the veins and through the walls of the rectum or bladder, as the case may be, and are voided in the faeces or urine.

The eggs hatch when they leave the body of the host, giving rise to free swimming forms called miracidia. The miracidia will enter the bodies of certain species of water snail, and if they do so, they will undergo development in the organs of the snail, and eventually (after about 60 days) emerge as free swimming cercariae. If the cercariae come into contact with the body of the appropriate host (by the latter drinking, washing with or bathing in the water in which they are living), they will penetrate the skin, reach the circulation and develop into adult schistosomes; the cycle thus begins afresh, and the excreta of the infected individual will, if it contaminates water in which the snails live, infect them.

There is no doubt that the passage of the eggs from the blood stream into the bladder and rectum, where they give rise to the presence of blood in the urine and stool, may result in serious and lasting consequences. Eggs may also find their way into other organs of the body, and they have been found post-mortem to be distributed in many tissues. Most authorities agree that serious disability is caused by bilharzia in persons (e.g. adult Europeans) who are infected for the first time. It is less clear how much disability is suffered by Africans who may have been exposed to infection from early childhood. The question still gives rise to controversy, and more data about it are highly desirable.

The treatment of the condition in man or animals is unpleasant, tedious and not always successful. To attempt to break the cycle by mass treatment of human beings is not, therefore, practicable. The other two methods of breaking the cycle and thus eliminating the disease are:

(1) To eliminate snails in all areas in which the disease is present.

(2) To prevent infection of snails by persuading or preventing human beings from urinating or defaecating in or close to water which is used for drinking, washing or bathing.

The second alternative, after all, demands no more than that the inhabitants of Africa should conform to the ordinary rules of sanitation as practised and enforced in civilised countries. Bilharzia, moreover, is by no means the only disease spread by the contamination of water supplies by human excreta. The prevention of such contamination would greatly help to cut down the incidence of the enteric fevers, poliomyelitis and of dysentry, and would decrease the risk of cholera. Protection of water supplies would not, of course, be achieved quickly, and would depend fundamentally on education and propaganda, particularly in schools. It would not, by itself, affect the incidence of fluke diseases in domestic animals.

The first alternative, that of killing snails, would involve the widespread use of molluscicides. Some species of snails, which inhabit water which is subject to seasonal drying are able to seal their shells and survive for long periods in dry mud, to emerge unharmed when water is again available. This means that not only permanent rivers and dams, but every stream and pool that appears during the rains, and holds water for any considerable period, is a potential snail habitat. Vast areas would thus have to be treated. Both molluscicides at present available, and the labour necessary for their application are expensive. All the molluscicides at present available kill fish as well as snails. Portions of the shores of Lake Victoria are known to be sources of infection. It seems unlikely that a sufficient local concentration of molluscicide could be maintained round the infected area of Lake shore. To attempt to treat the whole lake would be quite impossible.

Since not all species of snail are infected by schistosomes, it is of great practical importance, particularly if the use of molluscicides is contemplated, to distinguish the "vector" species. It would be a waste, both of molluscicides and labour to treat areas where only harmless species lived. Some species are at present known to be vectors, but the list is certainly very incomplete. It has been said that our knowledge of snails is no more complete than was our knowledge of mosquitoes, when that insect was first identified as the vector of malaria. The need for more extensive study is therefore obvious. Attention is of course being paid to other possible methods of snail control, e.g. by the introduction into dams, streams, etc., of snail-eating fish.

Mr. W. F. J. McClelland arrived at the Institute in September, 1955, under Research Scheme R/166. On his way to

East Africa, he spent a month in Egypt and the Sudan where he saw snail control schemes in operation. In Egypt, Dr. E. G. Berry, of the U.S. National Institutes of Health, was directing a scheme for the eradication of snails, using sodium pentachlorophenate. A new technique for snail control has been developed in the Gezira Irrigation area in the Sudan. This involves complete eradication of the snails already in the canals by sulphation, followed by the use of a permanent chemical barrier consisting of bags of copper sulphate placed across canal intakes, to prevent the re-entry of snails. The success of these methods can hardly be said to be yet established.

The work to be undertaken in Mwanza consists of an investigation of snail vectors of schistosomiasis. Equipment and facilities were, at first somewhat limited and, consequently, early work was concerned with the identification of the likely snail vectors of schistosomes found in the area. With the arrival of more equipment, it has been possible to start experimental work on the susceptibility of snails to infection, and the identification of schistosomes causing natural infections in snails. Attention is being concentrated on snails which are likely to transmit Schistosoma haematobium. It is probable that some of these snails will be found to act as intermediate hosts of cattle schistosomes as well.

The systematic and experimental work is intended to be a preliminary to trials of molluscicides. It is considered that the identification of snails and the recognition of the species acting as intermediate hosts of schistosomes is essential to any large-scale control scheme. At a later stage in the investigation it is hoped that copper sulphate and sodium pentachlorophenate will be tested in the laboratory and, later in small-scale field trials with a view to determining the more suitable material for use under East African conditions, and the best method of application. One such trial, on a dam near Mwanza, was carried out by Mr. Rhodes-Jones, in the earlier part of 1955. It appeared that comparatively small quantities of copper sulphate, suspended in bags from floats, was effective in these particular conditions.

Ecological work now in progress is directed chiefly towards finding out if there is any fluctuation in the size of the snail populations in different habitats, and also if the rate of infection of snails with schistosomes varies during the course of the year. These factors may be of great importance in deciding the best time of year for dosing the habitats with molluscicides. Another object of this work is to attempt to determine the characteristics which make a habitat suitable for snails.

7/21 PARE-TAVETA MALARIA SCHEME, TANGANYIKA PROGRESS REPORT. JANUARY-DECEMBER, 1956

Additional information on the insecticide aspects of the Scheme are to be found in the C.P.R.U. Arusha, Progress Reports.

The first residual spraying cycle with dieldrin was carried out from June to November, 1955, when 13,280 houses were treated. In the second spraying cycle from February to June, 1956, the wall dosage aimed at was 0.4 g/sq metre. 50% dieldrin wettable powder and Eclipse stirrup pumps were used. Mosquito control has generally been very satisfactory.

The densities of *Anopheles gambiae*, the predominant anopheline before spraying, have been considerably lowered, and it is only in certain of the swamp villages (Ndungu, Kihurio and Mkomazi) in the South Pare district* that significant numbers have been caught.

TABLE I

Summary of hut densities of vectors before and after dieldrin treatment

	Before Dieldrin June-Aug. 1955	After Dieldrin June-Aug. 1956	Per cent reduction
Taveta Area:			
A. gambiae	5.7	0.06	98.9
A. "funestus"	12.7	0.03	99.8
South Pare:			
(Main road villages)			
A. gambiae	4.7	0.1	97.9
A. "funestus"	11.3	0	100
(Swamp Villages)			
A. gambiae	38.1	1.12	97.1
A. "funestus"	56.7	0	100

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* Footnote: A map of the Pare-Usambara Region is appended.

There was some indication of increase in numbers among other anophelines in April, 1956, notably *A. rivulorum* in the Kihurio area, but the latter fell to the normal pre-spraying level after 3 months. In S. Pare, all adult mosquitos of the "Funestus" group, caught since shortly after the first dieldrin treatment, have been *A. rivulorum*. In the Taveta area, adult females resembling *A. funestus*, which were found in outside box shelters, are probably *A. machahoni*. Larval searches in both areas failed to yield *A. funestus* which thus appears to have disappeared with great rapidity after spraying.

A large increase in numbers of culicine mosquitos in Taveta huts early in 1956 was followed by a 32% reduction during April to August, 1956, compared with the same months in 1955, indicating that the increase was an effect of heavy rains rather than residual spraying. In S. Pare there was a 76% reduction of culicines in the main road villages and a 24% increase in swamp villages from April to August, 1956, compared with the 1955 figures.

Up to the end of November, no *A. gambiae* from houses or outdoors have been found to be infected. There does not appear to be significantly more exophily by *A. gambiae*.

An indication of the age structure of *A. gambiae* populations is given by the proportion of young nulliparous females, estimation of which involves the identification of unfertilised and recently fertilised females. The latter are characterised by the presence of a mating plug in the common oviduct, and are referred to as "plug positive".

TABLE II

Age grouping of *A. gambiae* in S. Pare District

	Pre-spray	Jan.-April 1956	Collected from	Aug.	Sept.	Oct.	Dec.
Numbers dissected			Bumba Lower) Mpirani)	862	356	162 106	363 235
Per cent unfertilized or plug positive			Bumba Lower) Mpirani)	25.1	22.2	38.9 9.4	16 17.4
Total per cent nulliparous	28-30	53-54	Bumba Lower) Mpirani)	33.9*	30*	55-57 19-20	36-39 40-41

* = estimated.

Old females have on the whole formed a rather higher proportion of the Bumba catches than in previous months. In houses in Lower Mpirani, the presence of an exceptionally old gambiae population was detected in October. This phenomenon, which may have been temporary, was followed at the beginning of the rains, that occurred five months after spraying, by a marked increase in house catches, a trend which became more marked still in December. This suggests that some falling off in the insecticidal effect of the dieldrin might possibly be occurring in the area, and special investigations are being initiated.

Experiments in which A. gambiae in cages are exposed (through a layer of mosquito netting) to dieldrin treated walls indicate that the dieldrin deposit is still very active after 6 to 7 months. Further experiments, in which the mortality of A. gambiae is counted within different periods after exposure to dieldrin for 3 hours, confirm that the insecticide acts slowly under natural conditions.

Surveys made on spleen and parasite rates suggest there has been a reduction in the transmission of malaria, at least in the younger age groups.

57/22 THE SUSCEPTIBILITY OF ANOPHELES GAMBIAE ON ZANZIBAR ISLAND TO INSECTICIDES

J. ARMSTRONG, Colonial Pesticides Research Unit, Arusha.

At the end of January 1957, the susceptibility of wild caught female A. gambiae from native huts to DDT, BHC, and dieldrin was assessed by the Busvine and Nash technique. Tests were carried out in native houses. Eggs from wild caught female mosquitoes were sent to Arusha and adults from them were tested under standard conditions using dieldrin.

	M.L.D. (%) for A. gambiae	
	Zanzibar mosquitoes	Arusha Colony
DDT	0.80	0.70
BHC	0.004	0.006
Dieldrin	0.042	0.08
	0.054*	

* adults from eggs.

The tests indicate that the A. gambiae on Zanzibar island have the same susceptibility to DDT as those on the mainland but are more susceptible to BHC and dieldrin than the mainland mosquitoes.

57/23 TSETSE RESEARCH PROGRAMME 1957-58

Dr. J. P. GLASGOW, Chief Entomologist, Central Tsetse Research Laboratory
Report to Trypanosomiasis Research Co-ordinating Committee, Meeting at Sukulu, October, 1956.

The investigations envisaged for the year 1957-58 are logical extensions although not in all cases continuations, of those described in the last Annual Report. Thus, rapid advances in our knowledge of the food of tsetse are being made. A considerable body of knowledge is accumulating about seasonal variations in feeding habits, and possible differences in feeding habits, between sexes and species. We now require to ascertain to what extent such differences are of the tsetse's own choice and to what extent they are imposed on the tsetse by variations in the possible hosts offering themselves. This is going to be a difficult study involving investigation of the daily habits of several species of game animals, but it is hoped that a research officer will become available to begin this work during 1957. Some evidence bearing on this point has come from Uganda, where, under a regime of selective shooting, *G. morsitans* apparently changed its main host without suffering inconvenience, but such observations cannot be interpreted certainly without much more background knowledge.

Consideration of the food of tsetse leads logically to the consideration of tsetse as food. The enemies of tsetse have been all too little studied. We have a number of isolated records, but no quantitative work. We do not even know, as Professor Buxton remarked, whether the beneficial results of successful discriminative clearing techniques are the result of depriving the tsetse of something it must have or of making it easier for some enemy to find the tsetse. Again it is hoped that a research officer will be available to begin the attack on this problem in the year 1957-58. His first task will be to list the possible predators-dragon flies, Asilidae, wasps, tree-frogs, birds and so on - and to select one group on which to concentrate. Having formed some idea of the importance of one group he will pass on to another, but of course the fact that one group of predators is found to be of little importance to *G. swynnertoni* in Shinyanga will not necessarily mean that the same group is of no importance to another species of tsetse somewhere else.

One of the most puzzling observations in the tsetse field is the long-term cycle of tsetse numbers, which is not made any easier to understand by the fact that similar cycles have been observed in a number of widely different groups of animal elsewhere in the world. It is possible that the projected study of the enemies of tsetse will reveal the cause of the long-term cycle, and perhaps of the short-term (annual) cycle as well. But it is also possible that the explanation of some or all of these phenomena will be provided by studies of physiology and behaviour. These two subjects must be studied together. For example, the response of an adult fly to changes in humidity can only be appreciated in conjunction with knowledge of the rate of water-loss in different humidities, and this is itself not simple as it depends in part on the individual history of the fly being studied. Reactions and inter-actions of this kind between tsetse and humidity, light and heat are being studied.

Such studies of the needs and instincts of the tsetse require to be integrated with field studies of the places actually occupied and the movements actually made by wild tsetse. We have made a very promising beginning on these lines with G. swynnertoni and to some extent with G. pallidipes in Shinyanga. We hope that these observations will be developed and extended to other places and other species. The study of the resting sites of tsetse in the field fits in with other studies besides those of the physiologist: its relation to the study of predation is obvious, and it has already made an important contribution to the study of the food of tsetse by providing samples of blood meals collected by an entirely new technique. Indeed, the only knowledge we have of the food of female tsetses has come as a by-product of the investigation of resting tsetse.

Work will continue on the laboratory maintenance of tsetse. This is of great ad hoc importance, since much physiological work requires to be repeated on healthy old flies of known history, which can only be provided from laboratory cultures. With present methods, however, laboratory bred flies cannot be regarded as healthy and normal and all results obtained with them require confirmation. Healthy cultured flies are equally required for transmission experiments at Tororo. The maintenance work is also of fundamental interest. For example, field observations on the food of tsetse given information on their nutrition habits, but cannot give certain information on their nutrition needs. This can come only from experimental maintenance.

Interesting information about the habits of G. pallidipes is being obtained by means of traps. This work will be continued and extended to include the designing of a trap to be used in low densities of G. pallidipes. Here again it is expected that field work will be helped by our behaviourists who may be able to explain why tsetses go into traps at all. If we had a clear idea about this we might be able to build a much more efficient trap, which would be of great use for making surveys in places where G. pallidipes is scarce.

During this period for the first time a botanist will become available for work on G. pallidipes areas. It is proposed to post him to the Lambwe where we know conditions are extremely favourable for this species. Besides enquiring into just what it is that makes this bush so suitable, he will investigate the historical processes which have brought this type of bush into existence, and consider whether it is now stable or whether it is changing by itself into another type which might be unfavourable to G. pallidipes.

Another botanist will continue to work on the relation of the vegetation to G. morsitans, with special reference to the eastern race orientalis.

57/24 INTERIM REPORT ON THE 100 ACRE EXPERIMENTAL AREA AT KIZIMBANI, ZANZIBAR. DECEMBER 1956

F. L. VANDERPLANK. Entomologist.

In October 1956, an experiment began at Kizimbani for the control of Pseudotheraptus wayi. The 100 acre experimental area containing 4800 coconut palms formerly consisted of several plantations and lies adjacent to the 100 acre control area.

Three spray applications were made of 10 DRDK (DDT + resin formulation) at a rate of 1½ gals/acre and mean droplet size of 70-90 microns with the Long Ashton Mist Blower, adapted in Zanzibar to give a satisfactory kill of Ps.wayi.

Records were kept for each palm of the yield, vidaka damage rate (V.D.R.) and of the presence or absence of Ps.wayi, Oecophylla spp., or Platymerus rhadamanthus. During the seven months preceeding the first spray application, the V.D.R. of 45.8% in the experimental area was slightly higher than in the control area. Immediately before the first spray the Ps.wayi index was 1:10 palms (80 palms searched), and similarly 1:9 palms (110 searched) for the control areas.

1st spray application: 50 acres only sprayed between 2nd and 5th October. In the experimental area *Ps.wayi* counts indicated a population reduction of at least 90% but the V.D.R. of 31.5% indicated a reduction of only 50%. In the control area *Ps.wayi* index was 1:8 and the V.D.R. rose to 59.1% possibly due to drought. The author considers the V.D.R. method is more reliable than counts of *Ps.wayi*.

2nd spray application: 100 acres sprayed between 5th and 11th November.

Experimental area:-	*Ps.wayi* index fell to 1:530 (530) V.D.R. 21%
Control area:-	*Ps.wayi* index 1:8 (362) V.D.R. c.60%

3rd spray application: 100 acres resprayed between 19th and 21st November.

Experimental area:-	By the week ending Dec. 7th, the V.D.R. had fallen to 0.8%. It then rose to 6.0% by the week ending Dec. 29th, when also 3 *Ps.wayi* neanides were found in 260 palms searched.
Control area:-	On the week ending Dec. 29th, the V.D.R. was 44.4%, and 22 *Ps.wayi* neanides were found in 270 palms searched.

This confirms that *Ps.wayi* are re-invading the area rapidly and have been most probably aided by the unseasonal dry conditions that prevailed during December.

Detailed observations on other species of insects on and around the palms are made. *Oecophylla* sp. and various other Hymenoptera, Diptera etc. were killed by the 10 DRDK sprays but many are making a good recovery. *Platymerus rhadamanthus* (Reduviidae) were frequently found prior to spraying but during 4 weeks after the 3rd spraying none were found in 1,200 palms searched.

57/25 REPORT ON THE TWO MAIN URTICARIA-CAUSING SPECIES OF LEPIDOPTERA

F. L. VANDERPLANK. Entomologist, Zanzibar.

Of the six species of Lepidoptera known so far to cause urticaria in Zanzibar, the two major pests are

Euproctis rubricosta Fawcett (Lymantriidae) and *Roeselia infuscata* Hmps. (Arctiidae). Both species occur on the Indian Almond *Terminalia cattata*; *E.rubricosta* is also found on the Flamboyant, *Delonyx regia*, and the Rain tree, *Pithecolobium saman*.

The adults of both species possess a tuft of barbed hairs on the last abdominal segment. The larvae have numerous easily shed spicules which are deposited at one end of the cocoon at pupation. The spicules are collected by the adult barbed hairs on emergence from the cocoon, and the female moths subsequently shed both hairs and spicules over the egg masses which are laid on the young growing shoots of the food plants. The barbed hairs and spicules may be easily dispersed by wind or by direct contact, and cause urticaria or irritation to human skin. The spicules of *E.rubricosta* (though probably not poisonous) cause intense irritation and, if inhaled, give a severe sore throat.

The fully grown larvae migrate down the tree trunk to pupate in dark situations. They may be parasitized by an ichneumon fly, in which case they remain on the leaves of the tree.

Low volume spraying of infested trees can reduce the caterpillars to low numbers, but this method is expensive, and rather more effective against the ichneumon parasites, which would not therefore be available to attack any remaining caterpillars. It is therefore recommended that tree trunks be sprayed with a 2 ft. wide band of an endrin plus resin formulation.

57/26 DAMAGE BY CERAMBYCID BEETLES IN TANGA PROVINCE

P. T. WALKER. Colonial Pesticides Research Unit, Arusha. Miscellaneous Report No. 170. December, 1956.

On a tea estate, altitude 4-5000 ft., shade trees, *Albizzia gummifera*, (Mimosaceae) were attacked by Cerambycid larvae. The damage is typical; a ring is bitten in the twig bark by the adult, the eggs are laid in the ring and the larvae bore a distance of four or five feet in the centre of the stem. The distal part of the branch breaks off and the whole branch wilts and dies. Adults have been found in June and July and large larvae in October 1956. Replacement of *Albizzia* by another shade species, *Gravillea*, which is not attacked is advisable. A single Cerambycid larva was also found on damaged *Markhamia*? species at the Sisal Research Station.

Damage has been found on two citrus estates. Young grapefruit and lemon trees show increasing damage. The egg case with 3 to 4 eggs is placed deeply in the stem in a macerated area half an inch below the ring in the bark. Larvae of various sizes were collected in September. Adults have been found in November and from March to April, one being identified as Tragocephala variegata Bert. Provisional control measures (cutting out infested branches and insertion of fumigant into larval holes) have been suggested until further details of the life history have been ascertained.

Kapok has received damage on two estates, an adult from one being identified as Tragiscoschema nigroscriptum which was earlier reported from two other parts of Tanganyika territory. It is apparently spread along inland behind the coast.

Note: The British Museum specialist working on this group is very keen to have more specimens of all stages of larvae and pupae, associated with adults of these insects, particularly 1st instar and pupae of Tragiscoschema. Adults should be dry, grubs preserved in spirit, labelled and sent to the author of this paper at Colonial Pesticides Research Unit, Box 204, Arusha, Tanganyika, or direct to the British Museum (Natural History), with appropriate references.

57/27 BIOLOGICAL CONTROL INVESTIGATIONS

F. J. SIMMONDS, Commonwealth Institute of Biological Control, c/o Imperial College of Tropical Agriculture, St. Augustine, Trinidad, B.W.I.
Extract of ninth resumé, December, 1956.

Control of Melittomma insulare (for the Seychelles)

Investigation of the biology of Atractocerus brasiliensis was concluded but no natural enemies were found. Arrangements were made for shipments of Rhizophagus dispar, a beetle predacious on the eggs of another Lymexylonid, to be sent from England to the Seychelles.

Control of Coconut scale, Aspidiotus destructor, (for Portugal)

At the request of the Portugese authorities Cryptognatha nodiceps was shipped to the island where a very severe attack of this scale had developed after it had been accidentally introduced into the island. The Coccinellid has become established and promises to give complete control of the scale.

Control of pod borers of pigeon peas (*Cajanus indicus*) (for Mauritius).

Several parasites of *Ancylostomia stercorea* have been shipped to Mauritius against *Maruca testulalis* and *Etiella zinckeniella*. One, *Bracon cajanus*, has been successfully established in Mauritius. *Maruca testulalis* was also studied here and one parasite, *Chelonus busckiella*, shipped in numbers to Mauritius.

Investigation of the possibilities of the biological control of some weeds (for Fiji).

(a) *Stachytarpheta* sp. Investigations have been concentrated on the insects (Cecidomyidae) attacking the seeds, and the biology of several species and their parasites has been worked out. Definitely phytophagous species can now be shipped.

(b) *Elephantopus mollis*. A Trypetid, *Tetraeuxaresta obscuriventris*, the larvae of which feed in the flower heads of the plant, has been studied.

Biological control of *Diatraea* spp.

Further releases of *Metagonistylum minense* and *Lixophaga diatraeae* have been made in Trinidad in an attempt to establish these parasites here. Again these attempts have been unsuccessful.

Paratheresia claripalpis has been successfully introduced into Dominica and Guadeloupe (Grande Terre), two very different climatic areas, and *Lixophaga* has been successfully introduced into Dominica, which a priori would appear to be very wet for the successful establishment of this species.

The life history of *Palpozenillia palpalis*, a parasite of *D.canella* (*Eodiatraea centrella*), *D.mullerella*, *D.grandiosella* and *D.lineolata*, has been worked out and a successful breeding technique devised. Large liberations have been made in Trinidad and British Guiana and smaller ones in St. Lucia and St. Vincent. Although some recoveries were made in British Guiana and Trinidad no permanent establishment has followed. The original material used for this investigation was obtained from Mexico and it is possible that a "race" from the N.W. territory of British Guiana might prove more successful.

Investigation of natural enemies of the West Indian cane-fly *Saccharosydne saccharivora* (for Jamaica).

Severe outbreaks of cane-fly occurred in Jamaica in 1952 and 1953 and search was made for parasites and predators in Trinidad. Augmentation of the natural populations of Coccinellids in the outbreak areas was tried without success. Shipments of a Dryinid, *Pseudogonatopus* sp., were made from Trinidad for liberation, but no recoveries have been made. Shipments of egg-parasites were also sent, but no liberations were made in Jamaica.

Control of *Calpodes ethlius* (for Bermuda)

Shipments of the egg-parasites, *Trichogramma* sp. and *Ooencyrtus* sp. were made from Trinidad, and both became established in Bermuda. There followed a considerable reduction in larval damage.

Control of *Oryctes* spp. (for the Seychelles, Fiji, New Guinea)

Shipments of *Leionota* spp. and *Pyrophorus* spp. have been made from Trinidad to the Seychelles, Fiji, and New Guinea for trial against *Oryctes*. So far there has been no indication that any permanent establishment has occurred.

Investigation of natural enemies of the padi-bug *Mormidea poecila* (for British Guiana)

The Commonwealth Institute of Entomology was investigating the problem of the padi-bug, and in connection with this a short investigation of parasites of *Mormoidea* was made in British Guiana. Egg parasites, *Telonomus* sp. were common and a Tachinid parasite of the adults - ? Beskia sp. - was not rare.

Investigation of parasites of the rice-stem borer, *Rupela* (*Scripophaga*) *albinella*, (for Indonesia)

Investigations in Trinidad (and also to a certain extent in British Guiana) showed that two species of *Telenomus* (one in each area) were very common. No other parasite was found. Small shipments of parasitised egg masses were made to Indonesia.

Investigation of the possibilities of biological control of the citrus weevils, *Prepodes* spp. (for Jamaica)

With increased planting of citrus in Jamaica damage from *Prepodes* is becoming increasingly important. Investigations as to the possibilities of biological control were made in Jamaica, and subsequently it has been decided to make tests with *Prepodes* of several egg parasites of *Diaprepes* occurring in Dominica.

Control of *Pseudaulacaspis pentagona* (for Bermuda)

There has been some indication that there has within the past few years been an increase in the infestations of the scale on oleanders - possibly associated with the spread of the Argentine ant, and also possibly with the alteration of eco-climate following loss of the cedars. Detailed investigation of this has been made and additional predators and the parasite, *Prospaltella berlesei* (from France), have been introduced. Of the predators *Cybocephalus* sp. and C. sp. *nr. semi-flavus* (Nitidulidae) and possibly *Coccidophilus citricola* (Coccinellidae), have been established. Parasite material has also been obtained from Japan.

Control of *Pulvinaria psiddi* (for Bermuda)

Recently outbreaks of this scale have occurred on oleander in Bermuda, and it appears to be increasing - again with the spread and increase of the Argentine Ant. Investigations have been undertaken with a view to obtaining biological control. *Cryptolaemus montrouzeri* (from California) and *Azya luteipes* (from Trinidad) are definitely promising and have been well established temporarily. *Pullus elegans* (from India) has also been tried. However it appears that predacious lizards (*Anolis grahami*) may be a major factor in control of both *Pulvinaria* and *Pseudaulacaspis* since they feed readily on the introduced Coccinellids.

Several parasites have also be tried. *Microterys Kotinskyi* was successfully introduced and appeared very promising, but a secondary parasite, *Procheiloneurus* sp. attacks a large proportion of *Microterys* and has, it would seem, probably prevented this promising parasite from exerting effective control of *Pulvinaria*.

Coccophagus spp. parasites of the younger stages of the scale, have also been tried, without establishment, in the field, as have two species of *Cecidomyids*.

OILS IN PESTICIDAL OPERATIONS

D. J. COLWILL. Colonial Pesticides Information Service, March, 1957.

General

Oils have been variously and extensively used for many years in pesticidal operations. Petroleum oil is said to have been used as an insecticide as long ago as 1787. Enormous quantities of petroleum oils are now used in horticultural sprays, principally to combat scale insects and mealy bugs. The well-known winter wash is based on petroleum oil, or tar oil, or a mixture of both. Oils of the petroleum type are now frequently employed in conjunction with synthetic insecticidal and fungicidal agents, which increase the toxicity of the sprays and widen the scope of these products. They are applied as emulsions, prepared by mixing the requisite amount of a concentrate with water, or as straight oil formulations, which are especially suited for use with oil fogging machines and for aerial application.

Oils for use against the larvae of mosquitoes, potential carriers of malaria, dengue and yellow fever, were not developed until the beginning of this century. The oils are still applied under certain conditions without additives but now more frequently contain one of the highly toxic modern larvicidal compounds which greatly increase their killing power. Oil-based pesticides are used in large quantities in adulticiding operations.

It was later discovered that certain petroleum oils were markedly toxic to plant growth. Their herbicidal activity was found to be associated with the aromaticity of the oil. Today selected aromatic-containing oils are used in ever-increasing amounts on a variety of crops, in silviculture, and for controlling weed growth by waysides, fences and in ditches. In many cases selective compounds are added to the oils to enhance their killing power and range of effectiveness.

Oils are then, today, widely used as solvent carriers of pesticides, either in the preparation of concentrates, generally emulsifiable, or for low strength sprays. The outlets for liquid pesticide formulations are legion:

> In public health, they are used for controlling insect pests and vectors of disease, by spraying dwellings, dairy barns and likely habitats, also by treating principal breeding grounds. In crop protection, formulations are available for spraying orchards, field

field crops, plantations and plants grown under glass, against the ravages of insect pests and diseases. In herbicidal practice, they are used either "straight" or fortified, emulsified with water or undiluted.

Oils as Carriers of Pesticides

Haller, H.L.[1]) has the following comments to make on solvent requirements:-

> "Emulsions are obtained by adding water to an emulsifiable - or emulsion - concentrate. Such concentrates are made by dissolving the insecticidal chemical and an emulsifying agent in an organic solvent. Usually the solvent is substantially insoluble in water as water-miscible solvents have not in general proved satisfactory.
>
> "Two general types of solvents have been used: (1) solvents, such as toluene or xylene, which evaporate after spraying or dipping to leave a deposit of the toxicant; and (2) non-volatile solvents, such as alkylated naphthalenes or a petroleum oil, which leave the treated surface coated with a solution of the toxicant in oil after the water has evaporated. Solvents such as toluene or xylene, under certain conditions, may constitute a fire hazard. The use of high-boiling aromatic solvents, such as the alkylated naphthalenes, may be dangerous when the emulsion is applied to animals.
>
> "Oil solutions of insecticidal chemicals are usually made with crude or refined kerosene and other petroleum oils. The selection of a solvent depends on its ability to hold the chemical in solution at ordinary temperatures, whether it is toxic to plants, and whether it constitutes a fire hazard. Sometimes more than one solvent is used, particularly when a preferred solvent does not dissolve sufficient of the insecticidal chemical to provide a solution of the desired concentration. An example is DDT in refined kerosene. This solvent does not dissolve enough DDT to permit the preparation of a 5 per cent solution. One has to add an auxiliary solvent. Auxiliary solvents dissolve larger quantities of the chemical. Cost, toxicity, and fire hazard keep them from being used as the only solvent. When a solution is made up of two solvents, one of which is a poor one and the other a good one for a particular chemical, the solubility in the mixed solvent may not equal the sum of the solubilities in the individual components. The quantity of a chemical that a solvent will dissolve varies widely with the temperature."

The desirable properties of a pesticide solvent are underlined by Nelson and Fiero2) who, in addition to solvency power, phytotoxicity and fire hazard, note the importance of colour and odour in the case of household products and of odour for agricultural applications; also the health hazard to man from solvent vapour.

A heavy aromatic naphtha is described as possessing a low boiling range (claimed to limit the phytotoxic risk by more rapid evaporation) and stated to be non-phytotoxic at normal concentrations; an excellent solvent even at low temperatures, without apparent risk to health and possessing a mild aromatic odour.

The following are listed:-

Initial boiling point (IBP)	°F	328
10%		395
50%		448
90%		495
Final boiling point (FBP)	°F	540
Specific Gravity		0.9267
API gravity		20.9
Kauri butanol value		96
Per cent aromatics		85.5
Mixed aniline point °C		25
Colour Tag Robinson		17
Flash Pt. P M C C °F		150

Goodhue15) recognises the suitability of xylene, in spite of its higher cost, for the preparation of emulsifiable concentrates of aldrin, chlordane, DDT etc. in terms of its solvent power, emulsifiability in water and its harmlessness to plants at normal dilution levels. High boiling isoparaffins (Soltrols) are described16). These are stated to be of low phytotoxicity, odourless and to possess excellent leaf spreading properties. The uptake of most pesticides in these oils is limited because of the high aliphatic content of the solvents. They appear well adapted however, for use as base oils.

The following properties are listed:

Physical and Chemical Property	Test Results	
	Soltrol* 140	Soltrol* 180
Distillation		
IBP °F	361	402
10%	367	423
20%	368	428
50%	372	441
70%	374	450
90%	382	464
95%	389	470
EP	400	481
Specific gravity, at 20/4°C	0.7595	0.7813
API gravity, at 20/4°C	54.8	49.6
Density of liquid, at 20/4°C	6.3	6.5
Refractive index, at 20°C	1.4247	1.4355
Viscosity at 100°F, Centistokes	1.541	2.20
Bromine number	0.44	0.62
Kauri butanol number	25.90	24.67
Aniline number, °F	185	198
Comparative spot dry time, minutes	54	150
Unsulfonated residue, %	97	98
Odour, residual	None	None
Odour, osmoscope	0	0
Flash, TCC, °F, 760 mm	141	181
Fire, COC, °F	165	205
Total sulfur, weight %	0.0022	0.0048
Color, Sybolt	+30	+30

* Registered Trade Mark, Phillips Petroleum Company.

Useful data on the toxicity of solvents and emulsifiers for formulating pesticides is contained in a report by Gast & Early17), who screened 77 emulsifiers and 86 solvents against six different test plants. Emulsifiers, as a class, appear several times more phytotoxic than solvents.

Many formulators of emulsion concentrates are guided by the World Health Specifications.3). No direct reservations are placed upon the type of solvents to be used but the finished product must comply with certain requirements which include product stability, flash point, acidity or alkalinity. U.S. Federal Specifications 0-1-5224) and 0-1-558a5) stipulate the nature of the solvent, indicating that "the solvent shall consist principally of aromatic petroleum derivatives and shall meet the following requirements when tested as specified".

Solvent requirements –	U.S. Federal Specifications	
	0-1-522	0-1-558a
Flash point Tag closed cup	115°F min	60 °C min
Distillation Range:		
I.B.P.	300°F min	150°C min
End point	600°F max	310°C max
Colour. ASTM Union Colorimeter	4 max	4 max
Degrees API at 60°F	11–21	9–22
Solubility of DDT (m.p. 108–9°C) at 30°C	–	35% min

Horticultural Spray Oils

Tree spray oils are generally classed as "dormant" or "summer" oils. "Dormant" oils are intended for use on hardy trees during the dormant period; "summer" oils for application to trees in foliage. "Summer" oils are more highly refined and are of lighter weight. This classification is considered now by Chapman, Riehl and Pearce6) to be an arbitrary one because of a trend toward using the so-called "dormant" oils after the onset of growth and using more highly refined products. The writers note that horticultural spray oils are derived from the fuel oils and light lubricant fractions of petroleum. Oils intended for foliage spraying are quoted as having U.S.R. values of 90–96% whilst, for products used on deciduous trees in the dormant period, values may range from 50–90 U.S.R. These oils are applied as oil-water emulsions. Pearce et al. showed that the insecticidal efficiency is related to paraffinicity of the oil.

Various specifications exist in regard to these products. In the United Kingdom, the Ministry of Agriculture7) has published specifications and methods of analysis for tar and petroleum oil based washes.

Washes applied in the U.S.A. are commonly petroleum based. Smith8) lists the following requirements (embodied in the 1955 official recommendations).

Viscosity (Saybolt, 100°F)	90-120 secs.
Viscosity Index Kinematic	90 (min).
Gravity API degrees	31 (min).
USR (ASTM)	90 (min).
Pour point	Not greater than 30°F
Homogeneity	Relatively narrow boiling distillate portion of petroleum.

Water emulsifiable petroleum oils for dormant or summer spraying are specified in U.S. Federal Specification 0-1-588a 9) as follows:-

	Dormant Oil	Summer Oil
Viscosity (Saybolt at 100°F)		
min	90	50
max	120	80
U.S.R. (% Wt)		
min	80	90
Distillation Range		
Distils up to 520°F min %		10
Distils up to 636°F min %	10	
" " " 636°F max %	25	
" " " 665°F min %		80

Note: 5% wt. (max) emulsifier added to spray oils before application.

Larvicidal Oils

According to Stage10) larvicidal oils should meet the following requirements:

reasonably quick kill
low surface tension
ease of penetrating debris and aquatic plants
low toxicity to plants and wild-life
inoffensive odour
non-toxic to humans
yield a persistent film
general availability
low cost.

Stage lists the following specification proposed by Nelson, Pierce and Donlan:-

Aromatic content	15%, preferably higher
Viscosity	not above 45 secs. at 100°F.
Interfacial tension	(spreading coefficient) 25 dynes/cm at 25°C max.
Specific gravity	0.75 minimum to less than 1.0 max.
Kauri butanol value (tolerance = 100)	35 minutes, preferably higher.
Aniline point	+ 60°C or lower
DDT soluble	not less than 5% at 0°C
Distillation	
IBP	not below 350°F
50%	440-480°F
FBP	not above 600°F

Herms and Gray[11]) quote the following specification for a petroleum oil larvicide:-

Specific gravity API	27-38
Viscosity	
Saybolt Universal @ 100°F	31-43
Initial boiling pt.	165°-230°C
Final boiling point	800°F (max)
Spreading Coefficient	17.0 (min)

Ginsburg's proposed specification is reported by the same writers as follows:-

Type of oil	distillate fuel
Gravity API	27-33
Flash	130°F or higher
Viscosity	
S.U. @ 100°F	35-40
Odour	not offensive
Distillation 10%	430-450°F
50%	510-550°F
90%	630°F or higher

Stage[10]) comments on the types of petroleum oils used as solvents and carrying agents of DDT in mosquito larviciding, notably fuel oil or diesel oil containing 5% DDT. The usual rate of application is given as 1 or 2 quarts of 5% DDT oil solution per acre of water surface. The addition of 1% spreading agent (eg. Triton B. 1956, (phthalic glycerol alkyd resin)) is sometimes made for larvicidal spraying.[18])

Insecticidal Oils

Household sprays and dairy cattle sprays frequently use odourless kerosene as the carrier.

It is reported by the U.S.D.A.18) that oil solutions of DDT and other pesticides are applied on a large scale in outdoor operations against adult mosquitoes. Solutions for use in fogging machines, such as the TIFA or Dyna-Fog, usually consist of 5% DDT in fuel or diesel oil or up to 10% in a mixture of fuel oil and an aromatic petroleum fraction, or other auxiliary solvent.

Requirements for fogging oils are noted by Collins19) as follows:-

"A minimum of 15% technical DDT should be retained in solutions at 32°F. Other toxicants should dissolve readily. (This high solvent power is required in order that each fog particle may carry a maximum load of toxicant.)

"The fog formed with a solvent should be dense enough, fine enough and persistent enough to ensure maximum penetration of underbush and crop cover.

"The solvent should be capable of forming uniform aerosol particles within a limited range under 100 microns in diameter.

"The solvent should in itself have a certain degree of insecticidal power.

"The solvent should be relatively non-toxic to human beings and to higher animals.

"The solvent should be relatively non-toxic to vegetation over a wide range of species and under the conditions where it is most useful as an insecticide or insecticide carrier.

"The solvent should offer a minimum hazard with respect to fire and explosion.

"The solvent should be non-staining, and at least in fog form, non-corrosive to paint, metals, plastics, and fabrics.

"The solvent should be cheap enough so that the advantages of its specific superior qualities as an insecticide fog oil will encourage its production and use.

"Actual tests on a sample of Sovacide F outdoor fog oil, according to data furnished by Socony-Vacuum Laboratories, showed the following characteristics:-

"Distillation, °F	
IBP	399
FBP	706
Gravity, °API	23.1
Flash, COC, °F	190
Saybolt, Universal viscosity at 100°F	34
Color, ASTM	$2\frac{1}{2}$
Technical DDT solubility at 32°F. %	15
Mixed aniline cloud pt. °F	120
Unsulfonated residue, %	37 "

According to the U.S.D.A.18), Mist Blowers (eg. Microsol) are sometimes preferred for treating residential areas. Also emulsions may then be used, instead of solutions, particularly if there is any likelihood of damaging vegetation.

For aerial application of pesticides fuel and diesel oils are widely used. Sometimes emulsions are employed in which case it is recommended that the concentrate should be prepared from an aromatic hydrocarbon with a minimum flash point of 140°F, to obviate the explosion risk and to prevent complete evaporation of the solvent from the spray droplets while drifting in the air.

Hocking and Yeo20) describe aerial experiments with coarse aerosols against tsetse in Uganda using oil solutions containing 10% w/v technical DDT (80% pp' DDT) or 11% w/v technical DDT (75% pp' DDT) or 5% SG 215 (26% gamma isomer BHC). The solvent consisted of equal parts by volume of Shell Power Kerosene and Shell Diesoline.

Herbicidal Oils

Development of the herbicidal uses of mineral oils has been traced by Crafts and Reiber12). Diesel and Stove oils had become widely used in the U.S.A. by the thirties for general weed clearance. They have also been used as selective sprays on carrots, but because of the risk of taint they have been supplemented for this purpose by the more refined selective oils such as the Stoddard solvent type, suitable for use on carrots, celery, parsnips, parsley, etc.

Specification for Stoddard Solvent[13]. Specifications of the U.S. Bureau of Standards for this product are as follows:-

Material: A petroleum distillate conforming to the requirements given herein.

Appearance: Clear and free from suspended matter and undissolved water.

Colour: Water-white or not darker than 21 by Saybolt chromometer.

Odour: Sweet.

Flash Point: Not lower than 100°F (Tag closed cup).

Corrosion Test: A clean copper strip shall show not more than extremely slight discoloration when submerged in the solvent for 3 hours at 212°F.

Distillation range: Not less than 50% shall be recovered in the receiver when the thermometer reads 350°F. The dry or end point shall not be higher than 410°F. No tolerance shall be allowed above 410°F.

Acidity: The residue remaining in the flash after the distillation is completed shall not show an acid reaction.

Doctor Test: Negative.

Sulphuric Acid Absorption Test: Not more than 5% of the solvent shall be absorbed by concentrated "c.p." sulphuric acid (sp.gr.1.835) (approximately 93.2%).

According to the British Weed Control Council[14], white spirits (boiling range 140-210°C) with aromatic contents between 15 and 25% are suitable for use in this Country. Vapourising oils (such as tractor vapourising oil) are not recommended, because of their varying phytotoxic properties.

"Mineral spirits" have been found suitable for controlling weeds in forest nurseries.

Oils effective as herbicides owe their toxic properties to their aromatic content. Their range of effectiveness and toxicity may be increased by addition of DNOC, PCP or DNSBP, or a growth regulating substance. They are then known as "fortified" oils.

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(3) World Health Organization, Geneva (1956). Specifications for Pesticides.

(4) U.S. Federal Specification 0-1-522 Feb.13, 1956. Insecticide, Dieldrin Emulsifiable Concentrate.

(5) U.S. Federal Specification 0-1-558a, Mar.24, 1954. Insecticide, DDT Emulsifiable Concentrate, Non-explosive Solvent.

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(17) Gast, R. and Early, J. (1956). Agric.Chem., 11, (4), 42.

(18) United States Department of Agriculture (1955). Circular 977.

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(20) Hocking, K.S. and Yeo, D. (1956). Bull.ent.Res., 47, (4), 631-644.

NOTE ON THE GLOSSARY OF SURFACTANTS

This is the second glossary of surface active agents to appear in PANS. The previous list was compiled by G.W. Wood as a supplement to his review "Surfactants for Insecticide Formulations" which appeared in PANS A 1955, Vol.1. No.4.

The circulation of the bulletin was limited to members of the government service at that time and though many copies of this review have since been distributed to workers in other fields there may be among our present subscribers some who have not received a copy but to whom it would be of interest. Such readers may therefore, like to know that reprints are still available through C.P.I.S.

The current glossary is the result of extensive revision and enlargement of the original list. Products have been arranged alphabetically and details of composition, properties and uses etc. have been brought together under the heading "Indications of Manufacturer". The supply source of each product is furnished through a numerical key.

Indicative of the current trend in formulation to use selected mixtures of two or more similar or different type surfactants is the appearance in the list of ready-to-use blends. Many recommendations also are presented for making up suitable mixtures from type constituents.

The advantages suggested for blended surfactants include:-

(1) reduction in screening time in selecting most effective surface-active material for particular formulations,

(2) applicability to a wider range of pesticidal formulations with concomitant high level of performance,

(3) greater degree of flexibility enabling formulations to be prepared which are efficient over wide range of water hardnesses,

(4) improved stability,

(5) greater or equal degree of effectiveness at lower surfactant concentration (synergistic effect).

There is, nevertheless, a wide selection of straight surfactants of many different constitutions for the benefit of formulators who prefer to devise blends to suit their own particular needs or for whom the straight material is entirely satisfactory.

An increasing number of polyoxyethylene derivatives are noted and a useful selection of anhydrous surfactants for formulating water sensitive pesticides.

GLOSSARY OF CURRENT SURFACTANTS

D.J. COLWILL. Colonial Pesticides Information Service.

Name	Ref.	Indications of Manufacturer
ABRIL 10 DC	2	High melting point speciality wax, supplied in white powder form, mp approx. 140°C. Recommended for the preparation of stable aqueous dispersions of oil based formulations. A special grade of Abril 10 DS (q.v.)
ABRIL 10 DS	2	High melting point wax (mp 140°C) of average particle size 5 to 15 microns, possessing good suspending power for oil based pesticides.
ABRIL PDS	2	High melting point wax (mp 165°C) of average particle size 5 to 15 microns, possessing good suspending power for oil based pesticides.
AL SERIES	15	Products at present available in development quantities only. Fatty alcohol condensates with ethylene oxide. Non ionic. AL 5. Speculative emulsifying agent, of possible interest as a wax emulsifier. AL 9. Speculative emulsifying and antistatic agent. AL 14. Speculative emulsifying and antistatic agent. AL 18. Speculative emulsifying and antistatic agent. AL 30. Emulsifying agent. AL 45. Emulsifying agent.
AP SERIES	15	Products at present available in development quantities only. Alkyl phenol condensates with ethylene oxide, Non ionic. AP 1. Solubiliser for products with longer ethenoxy chain. AP.5. Emulsifying agent. AP 6. Effective emulsifying and wetting agent for use in formulating pest control products.

Name	Ref.	Indications of Manufacturer
AP SERIES (Contd)	15	AP 14. Effective emulsifying and wetting agent for use in formulating pest control products. AP 25. Good wetting agent for use in phosphoric acid solutions.
AGRILAN A	16	Blended anionic/non-ionic emulsifying agent. Recommended especially for emulsification of toxaphene and chlordane. In conjunction with Ethylan LD and Ethylan TU (q.v.) for the emulsification of DDT, BHC, Aldrin, Dieldrin and Phenoxyacetic acid esters in all types of solvent, and DNOC in aromatic solvents.
AMINE HPL	10	Stearin dimethylamine 100%. Water dispersible, oil soluble amine, for emulsifying purposes.
AMINE OL	10	Olein dimethylamine 100%. Water dispersible, oil soluble amine, for emulsifying purposes. Both amines HPL & OL are stated to possess herbicidal properties towards grass and to be suitable for controlling termites.
ANSA	18	Alkyl naphthalene sulphonic acid. Thick brown, strongly acid liquid. Active matter 70% min. Water content 22% min (approx.) Free sulphuric acid. Balance. Useful spreader for agricultural sprays containing mineral acids.
APHROSOL FC	15	Solution of sodium alkylnaphthalene sulphonate. Anionic, neutral, brown coloured clear liquid, readily soluble in hot or cold water. Wetter and sticker in the preparation of pest control products.
ATLOX 3335	13	Alkyl aryl sulphonate blended with polyoxyethylene sorbitan esters of mixed fatty and resin acids. Clear to hazy brown liquid of sp.gr. 1.05 at 25°C; pH, 10% disp. H_2O, approx. 8; HLB = 13; Flash point approx. 106°F. Water content 0.5% max. Soluble

Name	Ref.	Indications of Manufacture
ATLOX 3335 (Contd.)	13	in most insecticide and herbicide concentrates and aromatic solvents. Insoluble in kerosene and paraffinic oils. Its use alone or in combination with Atlox 8916P or Atlox A 52 (q.v.) is suggested with aldrin, aramite, BHC, BHC/DDT, butyl and isooctyl esters of 2,4-D, 2,4,5-T, chlordane, DDT, dieldrin, heptachlor, heptachlor/DDT combinations, lindane, methoxychlor, parathion, strobane, TDE, thanite, toxaphene, and toxaphene/DDT combinations.
ATLOX 8916 P	13	Polyoxyethylene sorbitan esters of mixed fatty and resin acids. An emulsifying assistant to use with Atlox 3335 (q.v.) Red brown, oily liquid of sp.gr. approx. 1.1 at 25°C. Insoluble in aliphatic oils; pH 10% disp. H_2O approx. 7; HLB 14.6. Acid number 1 max; Hydroxyl number 100-130. Viscosity cp at 25°C 1100-1300; Water content 1.0% max.
ATLOX A 52	13	Sorbitan mono fatty acid ester. An emulsifying assistant for use with Atlox 3335. (q.v.) Dark red viscous oily liquid (will gel on standing) of sp.gr. approx. 1.0. Soluble in aliphatic and aromatic solvents. Dispersible in distilled water. HLB, 4.3; Acid number, max.7; Saponification number, 145-160; Hydroxyl number 160-185. Water content 0.5% max.
CAISOLENE OIL HS	15	Aqueous solution of the sodium salt of a highly sulphated oil. Anionic, neutral, golden yellow coloured liquid readily soluble in cold and hot water in all proportions. Solutions are stable to dilute mineral and organic acids, alkalis, hard water and many salts. Primarily used as a wetting agent.
CASA 57 EF	24	100% active cationic emulsifier for waxes. Compositions formed by melting together Casa 57 EF (10-20%) with paraffin wax are crystal clear when hot, cooling to hard,

Name	Ref.	Indications of Manufacturer
CASA 57 EF (Contd.)	24	homogeneous waxes. These mixtures can be easily emulsified in boiling water to yield fine milky suspensions. Casa EF is a very pale coloured soft solid wax which melts to a crystal clear, light orange liquid.
CASA 58 EF	24	100% active cationic emulsifier for oils. 2-5% in oils yields an easily emulsifiable oil in water emulsion. Casa 58 EF is a pale coloured, clear thick viscous oil.
CASA 51 LR	24	100% active cationic wetting agent. Thick viscous liquid forming clear solution with water or dilute acids. High surface active efficiency. pH (water) 7-9.
CASA 61 LR	24	100% active cationic wetting agent. Viscous light brown clear liquid soluble in water and dilute acids to form clear, foaming, highly surfacd active solutions. pH (water) 6-7.
CASA 121 LR	24	100% active cationic. Soft, pale coloured, waxy material melting by slight warming to a crystal clear orange liquid. Soluble in water and dilute acids. It is especially useful as the wetting agent for cold acid solutions where good colour and high surface activity are required. pH (water) 6-7.
CASA 181 LR	24	100% active cationic. Clear, thick liquid soluble in water and dilute acids. It has good cold acid fastness. pH (water) 7-9.
CASA 181 ALR	24	Cationic wetting agent (100% active). Soft viscous resinous material melting easily to a clear liquid. It can be diluted easily to a 10% crystal clear solution for use as a stock solution. It has the highest acid fastness of all surfactants in the Casa LR. series. pH (water) 7-9.

Name	Ref.	Indications of Manufacturer
CIRRASOL OD	15	Deodourised brand of Lissolamine A 50% Paste (q.v.) in more dilute form. Active ingredient is cetyl trimethylamine bromide. Cationic, cream coloured paste.
CITHROL A	7	Nona ethylene glycol mono-oleate. Brown fluid of slight odour sp.gr. 1.02 at 15.5%. Sap value 92.7 mg; moisture 0.3%; acidity as oleic 1.36%; pH 6.9; flash point 215°C. Dispersible in cold water, Soluble in white spirit (hazy). Completely soluble in xylol, ethyl acetate, meths, oleic acid and arachis oil. Powerful non ionic emulsifier of the O/W class, for oil fats, waxes and other materials. For use in agricultural and insecticidal sprays.
CRILL K 1	7	Sorbitol mono-laurate. Non ionic. Clear, fawn to light brown coloured thick viscous liquid soluble in mineral oil, alcohol, xylol, toluene, acetone, cellosolve, carbon tetrachloride; dispersible in water, alkalis and acids and solutions of acids and electrolytes. Acidity less than 3%, sap value 170 mg, pH 6, sp.gr. at 15.5°C = 1.06. Use 7-10% in agricultural insecticides. Non hazardous and non irritant.
CRILL K 3	7	Sorbitol mono-stearate. Non ionic. Hard fawn coloured waxy solid, insoluble in water; soluble in mineral oil, olive oil, carbon tetrachloride, ethylene glycol and xylol, slightly soluble in alcohol. Soap free edible wax and W/O emulsifier. Resistant to aqueous solutions of pH 0.5 to 12. Acidity less than 3%, sap value 142, sp.gr. 0.985 at 15.5°C. Use as auxiliary emulsifier in miticide and insecticide O/W emulssions and oil sprays.
CRILL K 16	7	Sorbitol mono-oleate. Non ionic technically pure grade. Viscous amber coloured material producing stable freeze resistant W/O emulsions and acting as an auxiliary O/W emulsifier and emollient. Oil soluble and

Name	Ref.	Indications of Manufacturer
CRILL K 16 (Contd.)	7	soluble in hydrocarbons etc. but insoluble in water. Stable to mineral acids and dilute alkaline solutions and solutions of electrolytes. Acidity (oleic) less than 3%, sap value 150 mg, iodine value 31, sp.gr. 0.990 at 15.5°C, flash point 455, viscosity at 60°C 710 secs (Redwood No.1).
CRILL S 6	7	Sorbitol mono-laurate polyoxyethylene derivative. Non ionic reddish brown liquid soluble in water, alkaline solutions and electrolyte solutions. Dispersible in hydrocarbons and vegetable oils. Soluble in alcohol; slightly foaming. Acidity 1% max, pH 6-7, sap value 57.7, iodine value 1.21. Use as wetting agent in aqueous systems.
CRILL S 8	7	Sorbitol mono-stearate polyoxyethylene derivative. Non ionic, light coloured pasty material, soluble in water, alcohol and aqueous solutions of acids, alkalis and electrolytes, toluol, cellosolve, carbon tetrachloride, ethyl acetate. Insoluble in olive oil, mineral oil and xylol. Acidity less than 3%, pH 7, iodine value 10. Use in oil emulsion sprays, benzylbenzoate dispersible concentrates, DDT dispersible powders.
CRILL S 10	7	Sorbitan mono-oleate polyoxyethylene derivative. Non ionic, light brown liquid, soluble in water, alcohol, toluol, acetone, cellosolve, methanol, and solutions of acids and electrolytes. Insoluble in mineral and vegetable oils and hydrocarbons. Acidity 1% max, sap value 47, iodine value 20. Emulsifier in insecticide concentrates; wetting agent for DDT powder.

Name	Ref.	Indications of Manufacturer
DISPERSOL T	15	Essentially disodium salt of methylene dinaphthalene sulphonic acid. Anionic, pale buff coloured powder, slightly hygroscopic. Readily soluble in water forming neutral solutions, which are stable in hard water and in presence of high concentrations of acids, alkalis and many salts. Dispersing and deflocculating agent.
EMPILAN AQ 100 LIQUID	18	Polyethylene glycol 400 mono-oleate possessing emulsifying, wetting and detergent properties. It is 99% active anhydrous liquid, yellow in colour and of slight odour. A 2% aqueous solution is slightly acid. It is soluble in cold water, ethyl alcohol, vegetable oils and hot hydrocarbon solvents; it is partly soluble in cold mineral oils. Recommended for the preparation of DDT emulsions.
EMPICOL LZ POWDER	18	Sodium lauryl sulphate (approx. 88%). Balance made up of free fatty matter, sodium chloride, sodium sulphate and water. Light fine uniform free flowing powder white to light cream in colour; slightly alkaline. Use in wettable insecticide powder.
EMULSIFIER EFM	6	Tri-hydroxy methylamino methaneoctadecenoate. Non ionic emulsifier. Dark brown moderately viscous oil, slightly soluble in water and soap solutions. Good solubility in most of the common oils or fats. Possesses anti-oxidising properties and will neutralise rancidity in fats. Fatty oils and mineral oils can be easily emulsified with 1-5% and 1-3% wt EFM respectively.
EMULSIFIER NEGO	6	Polyoxyethylene oleate. Non ionic, brown liquid with faint pleasant smell, Soluble in water, alcohol and hydrocarbons. It gives increased wetting and emulsification in conjunction with wetting agents and found suitable for preparations of insecticide emulsion concentrates based on DDT, BHC etc.

Name	Ref.	Indications of Manufacturer
ESTAX 5	25	Glyceryl monostearate (powder or lump). Use in grafting adhesive: Estax 5 (12%), Castor oil (3%), Rosin (62.5%), Yellow Beeswax (12.5%), Charcoal (10%).
ESTAX 37	25	Polyglycol 400 mono-oleate liquid. Use 4-6% w in conjunction with 2% lauric diethanolamide to prepare emulsion concentrates containing DDT, BHC in xylene. Use neutral grade for 2.4 D ester emulsion concentrates.
ESTAX 53	25	Polyglycol 400 mono-laurate viscous liquid. Use 5% in conjunction with 2% oleic diethanolamide to formulate dieldrin emulsion concentrate based on xylene.
ETHYLAN BCP	16	Non ionic polyglycol ether. For general emulsification in aromatic solvents. Can be used in conjunction with Ethylan ENT (q.v.)
ETHYLAN BSE	16	Blended non ionic emulsifier. Of use with certain aromatic solvents for general emulsification; also for pyrethrum extract in Shell Oudina and Risella Oil in conjunction with Ethylan LD (q.v.); for emulsification of DNOC and other nitro-bodies in aromatic solvent. The solution may be cloudy and should be cleared by the addition of 1% Ethylan OE (q.v.) Iranolin solvent KEB is readily emulsified by Ethylan BSE (3%-5%).
ETHYLAN ENT	16	Neutral. Non-ionic polyglycol ether based on an alkyl phenol (90% active). Yellow viscous liquid of slight odour gelling at -10°C. Oil soluble emulsifying agent for mineral oils and fortified mineral oils, certain of which may require the use of a coupling agent such as oleine, cety/oleyl alcohol, Ethylan SD etc. to obtain improved stability. Ethylan ENT is

Name	Ref.	Indications of Manufacturer
ETHYLAN ENT (Contd.)	16	essentially a hydrophobic surface active agent. Use in conjunction with Ethylan BCP, SW, etc. if greater hydrophilic character required.
ETHYLAN ENT EXTRA	16	100% active form of Ethylan ENT (q.v.)
ETHYLAN LD	16	High active coconut diethanolamide. Use in conjunction with Agrilan A (q.v.) to provide a combination of more hydrophobic nature.
ETHYLAN OE	16	Non ionic condensation product of fatty alcohol and ethylene oxide.
ETHYLAN TU	16	Alkyl aryl polyglycol ether based on alkyl phenol (100% active). Neutral, pale straw coloured, viscous liquid of faint odour, clouding at 41°F - 50°F and gelling at 32°F and stable to acids, alkalis and metallic salts. Soluble in alcohols, benzene, ether and water in all proportions. Suggested as emulsifying agent for aromatic hydrocarbons and mineral oils and in conjuction with Agrilan A to provide a combination of a more hydrophilic nature.
FIXANOL C	15	Technical grade of cetyl pyridinium bromide. Anhydrous cationic, brown coloured low melting soft solid. Soluble in cold and hot water (slightly acidic reaction) in many organic solvents and in certain oils and waxes. Clear stable solutions can be obtained in the presence of acids and salts such as sodium sulphate, calcium chloride, etc. Use as wetter, emulsifier and dispersing agent.
FIXANOL VR	15	Technical grade of tetradecyl pyridinium bromide. Anhydrous cationic brown coloured soft solid of low melting point. Properties similar to Fixanol C (q.v.) but with higher maximum solubility and greater wetting out in aqueous solutions.

Name	Ref.	Indications of Manufacturer
GA WETTING AGENTS	13	Polyoxyethylene derivatives for use as agricultural wetting agents.
GA 1250	13	Polyoxyethylene sorbitan mono-oleate combined with substances containing free carboxylic groups. For preparation of lindane wettable powder.
GA 4250	13	Polyoxyethylene ester of a mixture of fatty acids and resinic acids combined with substances which contain free carboxylic groups. For preparation of lindane wettable powder.
GA 5260 GA 5590	13	Polyoxyethylene stearate combined with substances containing free carboxylic groups. For preparation of dieldrin, BHC, lindane, DDT wettable powders.
GA 6260 GA 6590	13	Polyoxyethylene ethers of fatty alcohols combined with substances containing free carboxylic groups. For preparation of dieldrin, BHC, DDT, lindane wettable powders.
GEMEX 29	8	Aliphatic nitrogen compound. Cationic emulsifier, soluble in water. For preparation of emulsion concentrates.
GP 2113	7	An ethylene oxide derivative, and an alkyl aryl poly ether alcohol. Clear light coloured viscous oily material containing only traces of moisture etc. and is practically 100% active. Specially formulated as a non-ionic O/W emulsifier for aldrin and dieldrin concentrates. Soluble in water, trichlorethylene, xylol etc.; insoluble in kerosene, mineral oil and white spirit. For emulsification of solvents, oils and insecticides.
L 53	6	Polyoxyethylene fatty acid ester. Light brownish oil in warm weather becoming pasty in cold. Faint pleasant aroma. Water soluble. Forms stable solutions. Non ionic wetter, very effective at low concentrations. Hydrolysed by strong alkalis, not affected by mild acids. Compatible with many oils

Name	Ref.	Indications of Manufacturer
L 53 (Contd.)	6	and organic liquids. Dissolves many organic insecticides such as DDT, HETP, chlordane, etc. and being substantially anhydrous does not affect their stability.
LANKROPOL WAD	16	Amine salt of a monoester sulphate. Use as wetting agent and spreader, particularly for amine salts of phenoxyacetic acids.
LANKROPOL WNA	16	Sodium salt of a mono-ester sulphate. Use as wetting agent and spreader particularly for inorganic salts of phenoxyacetic acids.
LENSEX	23	Paste form of Teepol (q.v.) 44% active.
LENSODEL A	23	Neutral wetting agent containing 35% sodium dinonyl phosphate in aqueous alcohol solution. Colourless viscous liquid sp.gr. 1.001 at 60/60°F, flash point 55°F, pH 6-7 (0.1% wt aqueous solution), stable down to 3°C. Compatible with anionics and water soluble non-ionics. It is very efficient in dilute solutions of strong alkalis but the wetting power is reduced in dilute acid solutions and in concentrations of electrolytes above 2% wt.
LISSAPOL C PASTE	15	Aqueous paste containing 28-32% w of the sodium salt of a sulphated cetyl/oleyl alcohol mixture. Anionic, cream coloured smooth paste soluble in cold or more readily hot water to form neutral or very slightly alkaline solutions, which are stable to hard water, acids, alkalis and many inorganic salts. Possesses wetting, dispersing and emulsifying properties.
LISSAPOL C POWDER	15	Anhydrous form of Lissapol C Paste, containing the same type and amount of active agent. Fine cream coloured powder.
LISSAPOL LS PASTE	15	Aqueous paste containing 20% sodium oleyl p. anisidide sulphonate. Anionic. Light fawn coloured paste. Soluble in cold or,

Name	Ref.	Indications of Manufacturer
LISSAPOL LS PASTE (Contd.)	15	more readily, hot water forming neutral solutions of outstanding stability to acids, alkalis, inorganic salts and hard water.
LISSAPOL N	15	Aqueous solution of an alkylated phenol ethylene oxide condensate. Non ionic amber coloured free flowing liquid above 10-12°C. Negative solubility temperature coefficient. Good stability to acid, alkali or salt media. Detergent, wetting agent and emulsifier.
LISSAPOL NX	15	Anhydrous form of Lissapol N (q.v.), the active ingredient being about four times more concentrated. Properties similar to Lissapol N. Brown coloured viscous liquid, pourable above 10°C. Soluble up to at least 10% in a variety of solvents; practically insoluble in mineral oils and white spirit. May be incorporated into powder products as wetting, dispersing or de-dusting agent.
LISSAPOL NXA	15	Similar to Lissapol NX (q.v.) but possessing a controlled low water content. Of special value for compounding water sensitive insecticides of the organophosphate type.
LISSOLAMINE A 50% PASTE	15	Aqueous paste containing approx. 50% technical cetyltrimethyl ammonium bromide. Cationic, cream coloured paste with slight odour of trimethylamine. Use as wetter, spreader, emulsifier and dispersing agent particularly under acidic conditions.
LUBROL E	15	Alkyl phenol condensed with ethylene oxide. Controlled low water content; essentially 100% active agent. Non ionic, pale amber to straw coloured viscous liquid becoming semi-solid below 0°C. Gives neutral to slightly alkaline reaction. Miscible in all proportions with aromatic hydrocarbon solvents but insoluble or only slightly soluble in paraffinic solvents and mineral oils. Forms clear solutions in cold water

Name	Ref.	Indications of Manufacturer
LUBROL E (Contd.)	15	becoming cloudy on warming. It does not ionise or form salts and possesses good chemical stability to acids alkalis and salts dissolved in water. It is similar in performance to Lissapol NX (q.v.) but having superior physical properties and appearance.
LUBROL G	15	Blended surfactant based on a non ionic ethylene oxide condensate. Brown coloured, neutral, viscous liquid giving stable emulsions in soft and hard water. Anhydrous emulsifier specially designed for use with paraffinic solvents.
LUBROL MOA	15	Similar composition to Lubrol W (q.v.) but with a shorter polyethylene glycol chain conferring better solubility in organic solvents and oils. Anhydrous, non ionic, neutral, brown viscous liquid which separates out at low temperatures (reversible). It forms emulsions which are stable to a variety of conditions and is recommended for emulsifying oils and waxes preferably in conjunction with Lissapol NX or Lubrol W.
LUBROL W	15	Anhydrous condensation product of a long chain fatty alcohol and ethylene oxide. Non ionic, light coloured, low melting soft solid forming neutral solutions, which do not ionise or form salts. It is recommended for emulsifying waxes and for preparing miscible oil type products.
MANOXOL N	11	Sodium di-nonyl sulpho-succinate. General wetting agent.
MANOXOL OT	11	Di-octyl sodium sulpho succinate (100% active). General wetting agent.
MB 320	22	Anhydrous cyclohexylamine lauryl sulphate. Anionic, cream brown waxy solid readily soluble in cold water and in many organic solvents such as benzol, xylol, kerosene etc.

Name	Ref.	Indications of Manufacturer
MB 320 (Contd.)	22	It is in general use as an emulsifying agent for insecticide concentrates containing DDT, BHC, 2,4-D etc. and is effective in low concentrations. Appears to function synergistically when mixed with non-ionics of the polyoxyethylene ether type, It is of special interest as an anionic oil soluble surfactant.
METANOL SDB PASTE	4	Alkyl aryl sodium sulphonate (40% active) possessing emulsifying, wetting and suspending properties; stable to hard water, acids and alkalies. May be added to powder products to improve spreadibility and penetration. Will facilitate passage of wettable powder sprays through nozzle orifices.
METAPOL NK	4	Polyoxyethylene glycol ethyl ether. Wetting, spreading and dispersing agent.
MULSOLS A, LEC, OE	4	Emulsifying agents of similar constitution to Metapol NK, to prepare emulsions of mineral oils for insecticidal spraying.
NANSA BX	18	Anionic wetting out agent. Non hygroscopic free flowing, white to fawn coloured powder in bead form with faint odour, consisting of: Sodium alkyl naphthalene sulphonate 40% min Moisture 5% max Sodium Sulphate Balance pH (1% solution) = 7.5-8.5. The wetting power of solutions is not affected by dilute acids, alkalis, divalent salts or hard water. For use in preparing insecticidal wettable powders and, at a concentration of 1%, as a spreader in agricultural sprays.
NANSA HS	18	A high active dodecyl benzene sodium sulphonate derived from tetra propylene polymer benzene hydrocarbon. Light fawn to deep cream powder consisting of:

Name	Ref.	Indications of Manufacturer
NANSA HS	18	Dodecyl benzene sodium sulphonate 78% ± 2% Water 5% max Sodium Chloride 0.5% max Sodium sulphate 15% ± 3% pH (0.4% solution) = 9-10. The powder is hygroscopic. Available in flake form as Nansa HS flake. (Crisp flake, cream in colour, with faint characteristic odour. pH (0.4% solution) 7-8.5). Possesses good wetting properties and is stable to acids alkalis, divalent salts and hard water.
NANSA S	18	Dodecyl benzene sodium sulphonate (40% active). A spray dried, non hygroscopic, free flowing powder consisting of: Active matter 40% (approx.) Sodium phosphate 2% Moisture 2% Sodium chloride Trace Sodium sulphate Balance It is a light powder in bead form, white to pale cream coloured, of very faint characteristic odour. A 0.4% solution is slightly alkaline in reaction. It possesses wetting and foaming properties. It is stable to acids alkalis and hard water. It may be used in sea water. Recommended as the wetting out compound in the formulation of DDT and BHC wettable powders.
NERVAN CFB	19	Sodium alkyl naphthalene sulphonate, 40% active. Anionic wetting agent for insecticide wettable powders.
NITRILE 12	10	Fatty acid nitrile. Described as insect repellent.
NITRILE KK	10	Fatty acid nitrile. Described as rodent repellent.
NONEX SURFACTANTS	8	Wetting and emulsifying agents of polyethylene glycol type.
NONEX 25	8	Polyethylene glycol 200 mono-oleate
NONEX 26	8	" " 300 " "
NONEX 30	8	" " 400 " "
NONEX 52	8	" " 600 " "
NONEX 139	8	Polyethylene glycol 400 mono-laurate
NONEX 501	8	Methoxy polyethylene glycol laurate

Name	Ref.	Indications of Manufacturer
NONIDET P 40 (TP 7136)	23	Polyethylene oxide condensate (100%). Neutral, non ionic, pale straw coloured, slightly viscous liquid of sp.gr. 1.060 at 60/60°F. Stable and clear between 0°C and 70°C. Compatible with all types of surfactants. Unaffected by acids or alkalis. Use as wetting agent.
NONIDET P 42 (TP 7143)	23	Polyethylene oxide condensate (approx. 27%) Neutral, non ionic, pale straw coloured, slightly viscous liquid of sp.gr. 1.027-1.029 at 60/60°F. Stable between 0 and 60°C. Turbidity likely at higher temperatures. Compatible with all types of surfactants. Unaffected by acids or alkalis. Use as wetting agent.
PEG ESTERS	19	eg. Polyethylene glycol esters; non ionic emulsifiers for general use.
PENTRONE T	9	Fatty alcohol sulphate. Light coloured powder with faint pleasant smell suitable as a general wetting agent. It dissolves readily in warm water and is stable to hard water, dilute acids and alkalis. Also available as paste and powder concentrate.
PERMINAL BX	15	Sodium salt of alkylated naphthalene sulphonic acid with a proportion of sodium sulphate and sodium naphthalene-beta-sulphonate. Anionic, fawn coloured powder, slightly hygroscopic. It dissolves readily in water and is stable in the presence of acids, alkalis and many electrolytes. It is primarily a wetting and dispersing agent.
PERMINAL COL	15	Combination of a fatty alcohol ethylene oxide type surfactant with an anionic agent of the highly sulphated oil type, with corresponding improvement in solubility and stability. Clear golden yellow liquid with a tendency to separate at low temperatures (reversible). Dissolves very readily in hot and cold water yielding neutral solutions. Soluble and stable in hard water and in the presence of quite high concentrations of mineral and organic acids, alkalis and salts. Wetting and dispersing agent.

Name	Ref.	Indications of Manufacturer
PERMINAL EML	15	Aqueous solution of a sodium alkylnaphthalene sulphonate together with a specially liquified colloid and other emulsion stabilising agents. Anionic, brown viscous liquid, pourable above 5°C, readily forming neutral aqueous solutions which are stable to the addition of alkalis, organic and mineral acids and many metallic salts, and to hard water. Of particular value in the manufacture of emulsions for horticultural sprays and two phase (mayonnaise) type O/W emulsions.
PERMINAL PW	15	Anhydrous form of Perminal EML. Buff coloured granular powder, slightly hygroscopic.
PETROMORS	17	Blends of mineral oil and oil soluble sulphonates. Anionic emulsifiers miscible in all proportions with oil and many organic solvents for preparing fine, stable emulsions.
PETROSOLS	17	Anionic water soluble petroleum sulphonates of low solubility in oils for use as wetters and spreaders.
POLAMINE	7	A powerful anionic emulsifier employing property characteristics of wool wax alcohols. Acidity as Oleic Acid 0.02-0.15% Saponification value 1.0 - 2.0 Iodine Value 6 - 8.5 It is a cream coloured material of slightly granular appearance with slight odour. It is soluble in cellosolve, carbon tetrachloride and ethylene glycol; insoluble in alcohols and acetone, and partly soluble in mineral oils. It is intended for the preparation of liquid O/W emulsions of mineral oils, vegetable oils and solvents.
POLYETHYLENE GLYCOL ESTERS	1	General purpose emulsifiers.

Name	Ref.	Indications of Manufacturer
POLYRADS	12	Products obtained by reacting technical dehydroabietylamine (Rosin amine D) with ethylene oxide.
POLYRAD 1100	12	Containing 11 moles ethylene oxide per mole Rosin Amine D. Use as cationic emulsifier for preparation of acid stable emulsions and emulsifiable concentrates such as 2,4-D herbicides. Concentrates can subsequently be diluted with either water or petroleum hydrocarbons.
POLYRAD 1110	12	Similar in composition and use to Polyrad 1100 but containing 10% by wt free Rosin Amine D.
POLYRAD 4500	12	Containing 45 moles ethylene oxide per mole Rosin Amine D. Recommended as a dispersing agent for incorporation of insoluble solids into aqueous systems. Good dispersion can be prepared using 4 to 6 parts Polyrad 4500 per 100 parts dry powder. It is suitable for cationic and non ionic systems.
QUERTON HPLES	10	Stearine dimethyl ethyl ammonium ethyl sulphate (100%). Cationic emulsifier, water and oil soluble. Querton HPLES is recommended for fruit washing and as a fungicide.
QUERTON 2 KKES	10	Dicocoa methyl ethyl ammonium ethyl sulphate (100%). Specially indicated for the preparation of DDT emulsions.
QUERTON OLES	10	Olein dimethyl ethyl ammonium ethyl sulphate (25 or 100% grades). Emulsifier; fungicide.
SINTRA WAX SE	2	Brownish yellow wax (lumps), setting point 65-67°C, sp.gr. (at 15°C) 0.98, forming stable aqueous colloidal solutions of wax with very good freeze/thaw properties. Emulsifies readily. Preparations containing up to 25% total wax solids are completely

Name	Ref.	Indications of Manufacturer
SINTRA WAX SE (Contd.)	2	mobile. They form translucent aqueous colloidal solutions since the particle size is extremely small, much smaller than of ordinary emulsions.
SORBESTER EMULSIFIERS	14	These are of three types. Type P Mixed esters of the sorbitans obtained by partial esterification of sorbitol with long chain fatty acids. Predominantly hydrophobic therefore oil soluble. Promote W/O emulsions. Type Q Produced by condensing ethylene oxide with the P type esters. Predominantly hydrophilic therefore water soluble. Promote O/W emulsions. Type PQ Mixture of P and Q types. Frequently more effective than the single emulsifiers.
For example: SORBESTER EMULSIFIER P 12	14	Sorbitan monolaurate. Almost colourless waxy semi solid, soluble in alcohol and most organic solvents. Easily dispersible in aqueous media. Melting point 25–30°C Acid value 8 Saponification value 175 Hydroxyl value 340 Use as spreading agent in agricultural sprays and as auxiliary O/W emulsifier for kerosene.
SORBESTER EMULSIFIER Q 12	14	Polyoxyethylene sorbitan monolaurate. Pale yellow liquid, soluble in water, alcohol and many organic liquids. Viscosity at 25°C 500 c/p SG at 15.5°C 1.08 Acid value Nil Saponification value 70 Hydroxyl value 135 For use as O/W emulsifier for kerosene, as

Name	Ref.	Indications of Manufacturer
SORBESTER EMULSIFIER Q 12 (Contd.)	14	'solubiliser' for dispersing oils in water, and as auxiliary W/O emulsifier for decreasing particle size without excessive milling.
TEEPOL L	23	Based upon higher alkyl sulphates. Pale amber coloured liquid soluble in hot or cold water of any degree of hardness to give clear solutions. Stable over wide pH range and in the presence of electrolytes.
TEEPOL 514	23	Slightly viscous amber liquid of sp.gr. 1.068 at 60/60°F; pH (2% aqueous) 8.9-9.1. Anionic wetting agent.
TERGITOLS	8	Wetting and emulsifying agents.
TERGITOL 7	8	Aqueous solution of sodium hepta decyl sulphate (25%). Anionic wetting agent.
TERGITOL TD TERGITOL TMN	8	Polyethylene glycol alkyl ether (100% active). General purpose non ionic emulsifiers.
TERGITOL P 28	8	Aqueous solution sodium dioctyl phosphate (25%). General purpose anionic wetting agent, insoluble in acid, stable in alkali.
TEXOFORS	9	Polyoxyethylene/fatty group combinations. General purpose emulsifiers. Products vary in appearance from pale straw/cream waxy solids (AL, B1, E13) to pale amber/brown liquids (CD, D1, F). The properties are conditioned by variation in the length of the oxyethylene chain and by the chemical nature of the hydrophobic group. Texofors are particularly applicable in the formulation of insecticides where an emulsion is required. Texofor A1 is used for emulsification of copper, lead and zinc naphthenates, usually in a medium consisting of approximately 70% oil and 30% water. Texofor DC, 65A3 and F4 have been found particularly useful for mineral oil emulsification, either alone or in conjunction with Texofor F.

Name	Ref.	Indications of Manufacturer
TEXOFORS (Contd.)	9	Texofor D40, in equal proportion with Texofor F, is suitable for the emulsification of ether-type insecticides; in such case, the addition of a small proportion of oleyl alcohol has been found to increase the stability of the emulsion. Emulsions of DDT in xylene and solvent naphtha can be readily obtained using 3% of Texofor F on the total emulsion. Texofor F, in conjunction with Collone AC, is being used with weed killers such as 2,4-D, using paraffin as a diluent. To obtain an emulsion of 2,4-D ester with water 10% Texofor F15 on the total emulsion is suggested. In the formation of emulsions of Di-methyl Phthalate for use as insect repellents Texofor D60 can be used. Texofors may be used for the emulsification of aldrin and dieldrin in various solvents. Where kerosene is the solvent 5% Texofor CD on total weight of the solution is recommended. With xylene as solvent 5% Texofors F or D20, or Collone AC may be employed. Gamma benzene hexachloride in aromatic solvents can be emulsified by Texofor F and Collone AC. Insecticidal powders may be rendered dispersible by spraying the powder with Texofor D1, either alone or preferably in a volatile solvent, during milling. To increase the wetting and spreading power of liquid spray products, Texofor F is most suitable, very small quantities being required to give effective wetting.
TRITON B 1956	5	Modified phthalic glycerol alkyd resin. Clear amber, non ionic, free flowing liquid of sp.gr. 1.055 at 25°C. Soluble in water, vegetable oils and petroleum spray oils. pH (5% solids) 7.2, viscosity (Saybolt) 245 secs. at 100°F. Use as spreader, depositing agent, sticker and oil emulsifier in insecticide, larvicide, etc. formulations.

Name	Ref.	Indications of Manufacturer
TRITON X 45	5	An alkyl aryl polyether alcohol. Anhydrous non ionic, light amber coloured liquid, sp.gr. 1.03-1.05 at 25°C. Miscible with most organic solvents and considered miscible in all proportions with mineral spirits, VM and P Naphtha and diisobutylene. Essentially insoluble in water and only slightly soluble in highly refined aliphatic solvents and oils. Flash point 510°F (Cleveland open cup); mild, slightly aromatic odour. Indicated as emulsifying agent for spray oils and other emulsifiable insecticides.
TRITON X 100	5	An alkyl aryl polyethoxy ethanol. Clear, amber coloured viscous liquid of mild odour. Sp.gr. at 25°C 1.059-1,068. Flash point over 300°F. Excellent stability over wide pH range. Miscible with alcohol in all proportions and readily soluble in 50% glycerin. Insoluble in straight chain hydrocarbons; slightly soluble in aromatic oils; readily soluble in cold water. Indicated as emulsifier for solutions of DDT, Rhothane D3, HETP, chlordane, chlorinated camphene, Lethane 384, lethane 60, rotenone extract and others.
TRITON X 114	5	For addition to Bordeaux mixture at a concentration of 0.025% to improve spray dispersions applied to banana trees. It assists suspensions to spread evenly over the leaf surface and to leave uniform deposits upon drying. Deposits are also rendered more weather proof.
TRITON X 151	5	A blend consisting of alkyl aryl polyether alcohols with organic sulphonates. Liquid anhydrous emulsifier of sp.gr. 1.04-1.06 at 25°C; viscosity approx. 200 Saybolt secs at 100°F. Soluble in most organic solvents including aromatic hydrocarbons such as xylene. Also soluble in aromatic petroleum derivative solvents. Relatively insoluble in petroleum fractions such as kerosene, etc. Soluble in many toxicant/solvent systems such as toxaphene/kerosene, chlordane/kerosene, etc.

Name	Ref.	Indications of Manufacturer
TRITON X 151 (Contd.)	5	Indicated chiefly for blending with Triton X 171 in order to form versatile emulsifier blends which will provide satisfactory performance for various toxicant/solvent systems in hard and soft waters.
TRITON X 155	5	An alkyl phenoxy polyethoxy ethanol. Anhydrous, non ionic amber coloured liquid of mild odour of sp.gr. 1.045-1.065 at 25°C. Viscosity 2100 secs at 100°F (Saybolt Universal Scale). Flash point 430°F. Soluble in aromatic petroleum solvents and in most other organic solvents with the exception of certain paraffinic petroleum fractions including insecticide base oils. Soluble in water below 75°C. Found useful for preparing emulsions in combination with other emulsifiers (particularly Triton B 1956 and Triton X 45). Suggested for use in preparation of insecticide emulsions for application as residual sprays, mosquito larvicides, livestock dips, etc.
TRITON X 161	5	A blend of alkyl aryl polyether alcohols with organic sulphonates. Liquid anhydrous emulsifier, amber clear, of sp.gr. 1.04-1.06 at 25°C; viscosity approx. 500 Saybolt secs at 100°F. Range of solubilities similar to X 151. It is suggested for use in pesticide formulations to be applied primarily in medium hard water areas (60-300 ppm approx.)
TRITON X 171	5	A blend of alkyl aryl polyether alcohol type and organic sulphonate type surfactants. Liquid anhydrous emulsifier of sp. gr. 1.04-1.06 at 25°C. Viscosity approx. 625 Saybolt secs at 100°F. Range of solubilities similar to Triton X 151 (q.v.) Triton X 171 alone is recommended for preparing toxaphene/kerosene and other systems for use in soft water.

Name	Ref.	Indications of Manufacturer
VANTOC AL	15	Aqueous blend of higher alkyl trimethylammonium bromides (10% active agent). Cationic straw coloured liquid which solidifies on cooling below 0°C. Dissolves in cold or, more readily hot water forming chemically stable neutral solutions. Bactericidal.
VANTOC B	15	12.5% aqueous solution based essentially on tetradecyl pyridinium bromide. Cationic, pale golden liquid forming slightly acidic chemically stable solutions in hot or cold water. Bactericidal.
VANTOC N	15	Blend of higher alkyl trimethyl ammonium bromides (over 90% active). White powder, chemically stable, forming neutral solutions in hot or cold water. Powder is slightly hygroscopic. Bactericidal.
VANTROPOL BQ	15	Combination of non ionic detergent with quaternary ammonium bactericide. Amber coloured clear liquid.
VYKAMOL 1B	6	Sorbitol mono-laurate. Water dispersible, non-ionic ester. Use to prepare O/W emulsions with Vykamol 6 B. Insecticide spreader, penetrating agent or wetting agent.
VYKAMOL 2B	6	Sorbitol mono-palmitate. Stabiliser for O/W emulsions. Insoluble in water, soluble in many organic solvents. Use in insect repellent creams and liquid paraffin emulsions.
VYKAMOL 3B	6	Sorbitol mono-stearate.
VYKAMOL 4B	6	Sorbitol mono-oleate. Useful O/W emulsifier. Chemically stable. Use in miticide emulsions.
VYKAMOL 5B	6	Sorbitol tri-oleate. Oily liquid soluble in most organic solvents. Stabiliser to O/W emulsions. Wetting agent and W/O emulsifier.

Name	Ref.	Indications of Manufacturer
VYKAMOL 6B	6	Ethylene oxide/Sorbitol mono-laurate derivative O/W emulsifier, soluble in water and many organic solvents, insoluble in petroleum ether and mineral oils. Especially effective in conjunction with Vykamol 1B. Wetting, solubilising, penetrating agent. Insect repellent emulsions.
VYKAMOL 8B	6	Ethylene oxide derivative of Sorbitol mono-stearate. Soluble in water and many organic solvents. Use in preparation of O/W emulsions especially in conjunction with Vykamol 4B.
VYKAMOL 10B	6	Ethylene glycol derivative of Sorbitol mono-oleate. Soluble in water and many organic solvents excluding mineral oil. Effective O/W emulsifier especially in conjunction with Vykamol 4B.
VYKAMOL 12B	6	Ethylene oxide derivative of Sorbitol tri-oleate, Dispersible in water. Soluble in many organic solvents to varying degrees. Wetting, solubilising and penetrating agent.
VYKAMOL GMS	6	Self emulsifying glycerol mono-stearate. Lump or powder. White to light cream product. Aids suspension of pigments in oils, etc. Acts synergistically on other surfactants.
W 303	25	Technical thickening agent. Can be mixed into lead arsenate wash as follows: W.303 4% gal 100 parts by wt. Lead arsenate 2 " " " Water 300 " " " The gel is made by vigorously stirring W 303 into water at 60°C.
ZYLAPOL DLB	4	Alkyl aryl sulphonate liquid (over 30% active matter). To improve stability of liquid emulsions; wetting, penetrating and foaming agent.
ZYLASIL BX	4	Dialkyl aryl sulphonic acid paste (40% active matter). Wetting and dispersing agent.
ZYLASIL WER	4	Dialkyl ether sulphonate liquid (60% active matter). Wetting and spreading agent. Effective in low concentrations.

References

1. A. Boake, Roberts & Co. Ltd.,
Carpenters Road, Stratford, London, E.15.

2. Abril Corporation (Gt. Britain) Ltd.,
Golden Mile Works, Bridgend, Glam.

3. Allied Colloids (Manufacturing) Co. Ltd.,
11 Gt. St. Thomas Apostle, Queen Street, London, E.C.4.

4. Keegan Dyestuffs & Chemicals Ltd.,
164 Garnett Street, Bradford, 3, Yorks.

5. Charles Lennig & Company (Great Britain) Ltd.,
26-28 Bedford Row, London, W.C.1.

6. C.M. Keyworth & Co. Ltd.,
Barnfield Works, off Newcastle Road, Leek, Staffs.

7. Croda Limited,
Croda House, Snaith, Goole, Yorks.

8. Gemec Chemicals Co.,
120 Moorgate, London, E.C.2.

9. Glovers (Chemicals) Ltd.,
Wortley Low Mills, Wortley, Leeds, 12.

10. Guest Industrials Ltd.,
81 Gracechurch Street, London, E.C.3.

11. Hardman & Holden Ltd.,
Manox House, Miles Platting, Manchester, 10.

12. Hercules Powder Company Ltd.,
140 Park Lane, London, W.1.

13. Honeywill-Atlas Ltd.,
Devonshire House, Mayfair Place, Piccadilly, London, W.1.

14. Howards of Ilford Ltd.,
Ilford, Essex.

15. Imperial Chemical Industries Ltd.,
Nobel House, London, S.W.1.

References (Contd.)

16. Lankro Chemicals Ltd.,
Bentcliffe Works, Salters Lane, Eccles, Manchester.

17. Manchester Oil Refinery Ltd.,
Twining Road, Trafford Park, Manchester, 17.

18. Marchon Products Ltd.,
Whitehaven, Cumberland.

19. Norman Evans & Rais Ltd.,
Dudley Road, Manchester, 16.

20. Petrochemicals Ltd.,
170 Piccadilly, London, W.1.

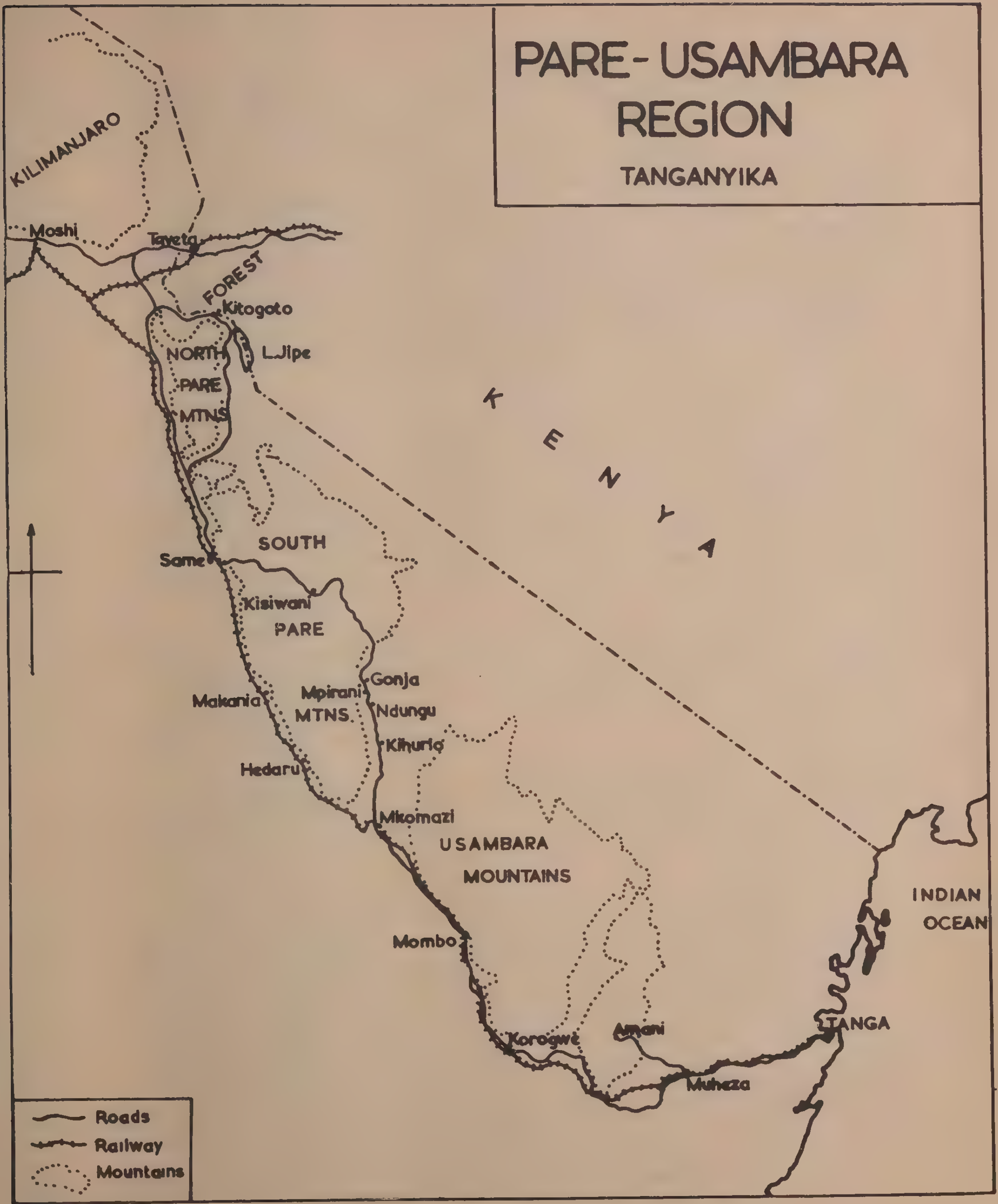
21. Rex Campbell & Company Ltd.,
7 Idol Lane, Eastcheap, London, E.C.3.

22. Ronsheim & Moore,
8 Buckingham Palace Gardens, London, S.W.1.

23. Shell Chemicals Company Ltd.,
Marlborough House, 15/17 Gt. Marlborough Street, London, W.1.

24. Thomas Swan & Co. Ltd.,
Consett, Co. Durham.

25. Watford Chemical Company Ltd.,
22/32 Copperfield Road, Canal Road, London, E.3.


PARE-USAMBARA REGION
TANGANYIKA
KILIMANJARO
Moshi
Taveta
FOREST
Kitogoto
L. Jipe
NORTH PARE MTNS
KENYA
SOUTH PARE
Same
Kisiwani
Gonja
Mpirani MTNS
Makania
Ndungu
Kihurio
Hedaru
Mkomazi
USAMBARA MOUNTAINS
INDIAN OCEAN
Mombo
Korogwe
Amani
TANGA
Muheza
Roads
Railway
Mountains

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NEWS ITEMS

(xiv) MEDITERRANEAN FRUIT FLY CONTROL IN THE UNITED STATES

(U.S. Department of Agriculture, Press Releases 1957).

Some indication is given of the extent to which attractants and baits have contributed to the success of the eradication campaign in the U.S. (chiefly Florida) against Mediterranean fruit fly. The problem of rapidly diminishing supplies of Angelica seed oil attractant has been solved by the timely discovery of the isopropyl ester of 6-methyl-3-cyclohexene-1-carboxylic acid (ENT-21,478).

Baits are applied to vegetation in areas which are shown, from inspection of the traps, to be infested. The baits are prepared from yeast and malathion and are distributed by aircraft or, sometimes, ground operated mist blowers. A natural substance in the yeast, enzymatic protein hydrolysate, attracts flies to the poisoned bait. Granular dieldrin, applied to the soil under known host trees, serves to destroy insects entering or leaving the soil.

Nearly 800,000 acres are stated to have received treatment since the campaign started, many several times over. The aggregate treated acreage is estimated at over 6,000,000.

(xi) MOSQUITO LARVICIDE CAPSULES

Gelatin capsules for applying larvicidal oil - developed by the R.P. Scherer Corporation, Windsor, Ontario, Canada - are now available from their Associates in the United Kingdom (216-222, Bath Road, Slough, Bucks.)

The capsules each contain 5.25 ml of larvicidal oil capable of treating 750 sq. ft. of unobstructed water surface. The present formula (used successfully in Canada against *Aedes* larvae) consists of DDT and gamma BHC (lindane) with two spreading agents dissolved in a mineral oil/xylene base. The larvicide is released when the capsule is placed in contact with water which penetrates the shell. Evacuation of the contents is assisted by an encircling elastic band. The approximate disintegration time is given as 10 mins at 60°F and 6 secs at 100°F.

The capsules are designed to provide a convenient means of applying larvicide particularly where, for example, sprays might be retained by overhanging foliage. They are claimed to be economical to use, easy to apply and safe to handle.

(xvi) METHYL BROMIDE

This fumigant is described in an illustrated booklet ("Embafume" methyl bromide 2nd edition) issued by the manufacturer, May & Baker Ltd. Details of its physical and chemical properties, typical uses, dosage rates and handling procedures are given. Susceptible insect pests are listed. Almost every insect pest infesting common stores products, it is pointed out, can be destroyed at any stage of development from egg to adult insect by methyl bromide. Rats and mice may also be killed at dosages below those normally required for insect fumigation. Its ability to penetrate deeply infested articles is attributed to its very slight water solubility, chemical stability and mobility, which properties also ensure rapid aeration during the ventilation period after treatment.

Various fumigation procedures are outlined including the treatment of barges, flour mills, goods-vans, ships, seedbeds and grain in silos. Notes are given on space and vacuum fumigations and on the use of gas-proof sheeting. It is of interest to note that although plastics may be attacked by the liquid, sheeting coated with a plastic or synthetic rubber is suitable for operational use.

Reference is made to the principal factors in efficient fumigation, namely dosage (concentration), exposure time and temperature (preferably 60°F or above); typical schedules based on these are given.

Preparatory measures, e.g. sealing, are described, also toxic hazards and methods of detection (i.e. addition 2% chloropicrin or halide lamp). It is considered safe material to handle, free from fire and explosive risks, and without harmful after-effects.

Physical Constants

Boiling point	3.6°C
Specific gravity (at 0°C)	1.732
Volume per lb. (at 0°C)	262 ml.
Vapour density (at 20°C; air equals 1)	3.27
Specific heat of liquid at 0°C	0.12 calories/Gm./°C.
Latent heat of vaporization at 10°C	61.8 calories/Gm.

Temperature °C	0	4	10	20	30	40	50
Absolute vapour pressure lb/sq. in.	12	15	17.5	25.5	35.5	48.5	65

'Embafume' conforms to the requirements of B.S.2710:56 for methyl bromide which are as follows:

Appearance:	A clean, colourless or pale straw coloured liquid.
Specific gravity:	Between 1.710 and 1.735 at 0°C/15°C
Boiling range:	At least 95 per cent distils at 760 mm. pressure between 3.5 and 5.0°C, initial ebullition not occurring below 3.5°C.
Residue on Evaporation:	Not more than 0.01 per cent w/w
Acidity:	Not more than the equivalent of 0.02 per cent HBr w/w.

(xvii) COMPARISON OF INSECTICIDES FOR MOSQUITO CONTROL

Results of preliminary tests to compare the effectiveness of various pesticides as mosquito larvicides have been received from Farbenfabriken Bayer, Germany.

The lowest concentration at which each active substance was adjudged effective against Aedes aegypti larvae is shown below. Parallel tests were also made by exposing fish, known to feed on Anopheles and Aedes larvae, to the same concentrations of insecticides as the mosquito larvae. Mammalian toxicity is also listed. Values for LD_{50} mg/kg rat per os are taken from "Toxicologie des Produits Phytopharmaceutiques" by Fabre and Trihaut.

The results have shown that Chlorthion combines the best effect against mosquito larvae (0.01 ppm) with the greatest safety factor regarding fish toxicity (1000 x) and the lowest order of mammalian toxicity (2000-500 mg/kg).

Pesticide	Larvicidal effectiveness (Concentration ppm)	Fish toxicity Safety factor	Mammalian toxicity grouping
E 605 ethyl ester	0.01		< 100
E 605 methyl ester	0.01	1000 x	< 100
Chlorthion	0.01	1000 x	2000-500
Dipterex (L 13/59)	0.1	1000 x	2000-500
Muscatox (21/199)	0.1	1000 x	500-100
DDT	0.1	100 x	500-100
Lindane	0.1		500-100
Aldrin	0.1	(Others) (are) ($\leqslant$ 10)	< 100
Dieldrin	0.1		< 100
Endrin	0.1		< 100
Diazinon	1.0		500-100
Malathion	1.0		2000-500

(xviii) TETRAM

Comprehensive technical data on Plant Protection Ltd's new scalicide/acaricide "Tetram", is now available (Technical Data Sheet No. 1, 'Tetram', Fernhurst Research Station, Nr. Haslemere, Surrey).

'Tetram' is the registered name in the United Kingdom for the commercial material containing 75% of the active ingredient which is amiton oxalate (0,0'-diethyl-S-(beta diethylamino) ethyl phosphorothiolate hydrogen oxalate. 'Tetram' is also known as 'Inferno' (Italy), 'I.C.I.' Amiton (Holland), 'Tetram' 75 (U.S.A.) and 'Metramac'.

It is described as a quick-acting systemic insecticide with prolonged residual effect and is particularly recommended for use on deciduous fruits, citrus and cotton for the control of mites and scale insects. Recommendations are based on extensive large scale trials. In the U.K. these chiefly relate to its power to control fruit tree red spider mite on apples, in concentrations of the order of 2 oz/acre as a single application in high or low volume.

The commercial product, dyed dark violet, is a free flowing non-dusty solid with mercaptan-like odour, melting at 80-90°C and stable under normal conditions of storage and in acid media. It will gradually decompose on prolonged storage above 40°C and is rapidly destroyed by alkalies, sodium hypochlorite and bleaching powder. It is readily soluble in water and polar solvents but is insoluble in hydrocarbons and other non-polar media. It is compatible with most pesticides other than the alkaline type and is completely non-phytotoxic. Like parathion, it is a powerful cholinesterase inhibitor and the standard precautions when handling this type of product must be carefully observed. High, in vitro, cholinesterase activity forms the basis of the described method of residue analysis.

The brochure summarises the results of world wide biological tests and residue checks. Notes are given on packaging, labelling, handling and suggested experimental uses. A conversion and dilution chart is included.

(xix) PESTOX 99

Fisons Pest Control Ltd. announce a new insecticide formulation containing schradan, for protecting crops from aphids. Recommendations relating to U.K. conditions are reproduced below. Edible crops must be treated well in advance of harvesting to avoid toxic residues in the product, the minimum period being 4 weeks if sprayed during April to July or 6 weeks (August to mid-September). Good cover and maximum absorption are obtained with a fine mistlike spray containing the product in high dilution. Any conventional orchard or crop sprayer suitably adjusted is satisfactory. Pestox 99 will decompose if left in contact with strongly alkaline mixtures such as Lime Sulphur or Bordeaux Mixture, but is compatible with many other pesticides. Careful handling is essential and the conditions set out in the Agricultural (Poisonous Substances) Regulations must be fully observed.

Noted advantages for using this formulation include the systemic action which allows the poison tq be absorbed directly into the sap stream so that pests hidden and protected in curled leaves or under webbing can be controlled and new foliage automatically protected as it grows; its selective action in safeguarding beneficial insects such as bees, ladybirds and hover fly larvae; and the harmless decomposition products containing nitrogen and phosphorus which are eventually available to the plant as nutrients.

Crop	Pest	Dosage per acre and application volume	Time of treatment
Brussels sprouts	Cabbage aphis	4 pints Pestox 99 per 100 gals in fine spray	July/August and not later than 15th September.
Cabbages) Cauliflowers) Broccoli) Greens)	Cabbage aphis	3 pints Pestox 99 in 100 galls.	Not later than 15th September.
Sugar beet mangolds	Green peach aphis Black aphis (blackfly)	4 pints Pestox 99 in 100 gals.	Immediately first aphids are seen in crops
Seed crops	Aphids	3 pints Pestox 99 in 100 gals.	May, before aphids develop colonies.
Steckling beds	Aphids	4 pints Pestox 99 in 100 gals.	(a) On harvesting of cereal crop if grown in cover crop. (b) 2 further sprays the last at the end of October.
Field beans	Blackfly	1½ pints Pestox 99 in 20 to 100 gals. low or high volume.	June, when blackfly first appears.

(xx) 'CHEM-VAPE'

'Chem-Vape' manufactured by Chemical Insecticide Corporation, 30 Whitman Avenue, Metuchen, New Jersey, U.S.A. is styled as "the one shot preplant soil treatment for the control of miscellaneous weeds, nematodes and soil borne insects and diseases." It is sodium methyl dithiocarbamate (anhydrous 31%) with a special penetrant (U 105) which ensures both its lateral and vertical distribution through the soil. Its lethal action is attributed to the penetrating gas formed on decomposition. The product is stated to be relatively non toxic to warm blooded animals but since it may nevertheless be irritating to the eyes, skin and mucous membrane, the usual precautions when handling toxic chemicals are advised.

The material disappears quite readily after application and planting can be carried out in treated areas 14-21 days later. Treatment depends upon such factors as temperature, soil consistency, method of application and nature of pest. Soils should preferably be kept moist, dosages should be increased on heavy soils and special care taken to seal very porous soils after treating. Against mematodes deep injection 6-10" below the planting row is necessary. Shallow injection (3"-5" deep) can be used for controlling soil diseases and weeds, or surface methods of application with, for example, hose proportioner, sprinklers and sprayers. Typical dosage recommendations include 1 quart Chem-Vape in 20-35 gallons water per 100 sq. ft. to seed beds and 25 gallons product per acre for preplant field treatment. It is also recommended for use in nurseries, orchards and on lawns.

Chem-Vape is stated to be effective against the following pests: nematodes, symphilids, wireworms and various grubs; soil borne fungus diseases including damp-off organisms such as Rhizoctonia sp., Fusarium sp., Verticillium, Armillaria, Phytophthora sp., affecting ornamentals and vegetable transplant beds; weeds, both annual and perennial (broad leaf species including grasses) and germinating seeds e.g. chickweed, Amaranthus sp., Lambs quarters, Bermuda grass, nut grass, water grass, purslane, Johnson grass, malva, dandelion, ragweed, wild morning glory, Russian knapweed.

(xxi) RECENT PROMOTIONS, TRANSFERS AND APPOINTMENTS

The following list compiled from the information supplied by the Colonial Office, includes only the officers whose duties will be concerned with entomology, pest control and related fields.

April 1957

Cox, J.K. Senior Agricultural Officer, North Borneo.	Assistant Director of Agriculture, North Borneo
Loizides, P.A. Agricultural Officer Class I, Cyprus	Senior Agricultural Officer (Research), Cyprus.
Mills, W.R. Agricultural Chemist, Uganda.	Officer in Charge, Serere, Uganda.
Winter, D.W. Agricultural Officer, Zanzibar	Agricultural Officer, Tanganyika.
Bulmer, I.G. Assistant Conservator of Forests, Sierra Leone.	Senior Assistant Conservator of Forests, Sierra Leone.
Fyfe, A.J. Conservator of Forests, Grade B, Federation of Malaya.	Conservator of Forests, Grade A, Federation of Malaya.
Setten, G.G.K. Senior Assistant Conservator of Forests, Federation of Malaya.	Chief Research Officer, Federation of Malaya.
Tamworth, I.P. Senior Assistant Conservator of Forests, Federation of Malaya.	Conservator of Forests, Grade B, Federation of Malaya.
Hanney, P.W.	Entomologist, Northern Nigeria. (first appointment)
Petrie, Mrs. C.M.	Temporary Records Officer, Department of Agriculture, Federation of Nigeria, (first appointment)
White, J.D.	Soil Conservation Engineer, Kenya, (first appointment.)

Edgley, R.	Chemist, Tanganyika. (first appointment)
Wood, Bdr. A.A.	Assistant Conservator of Forests, Northern Rhodesia. (first appointment)
Collings, D.F., M.R.C.V.S.	Veterinary Officer, Tanganyika. (first appointment)
Pederson, A.H.E., Vet.Med. Copenhagen	Temporary Veterinary Officer, Northern Nigeria. (first appointment)
Messing, J.H.L.	Soil Scientist, British Guiana. (first appointment)

May 1957

Hanschell, M.A.G. Development Commissioner, St. Lucia.	Director of Agriculture, British Honduras.
Jones, T.H. Assistant Government Chemist, Northern Nigeria.	Government Chemist, Northern Nigeria.
Kirby, N. Government Chemist, Jamaica.	Government Chemist, Kenya.
MacGregor, D.E., B.Sc., M.R.C.V.S., Principal Veterinary Officer, Northern Nigeria.	Chief Veterinary Officer, (Animal Industries), Northern Nigeria.
Sutton, C.D.	Soil Chemist, Sarawak. (first appointment)
Van Someren, V.D., M.B.E., B.Sc., Ph.D.	Biologist, Kenya, (first appointment)
Marshall, B.	Assistant Government Chemist, Federation of Nigeria. (first appointment)
Owen, G., M.R.C.V.S.	Veterinary Officer, Nyasaland. (first appointment)

June 1957

Abbott, S.H. Superintendent of Agriculture, Antigua, Leeward Islands.	Superintendent of Agriculture, St. Kitts-Nevis-Anguilla, Leeward Islands.
Butters, B. Agricultural Chemist, Uganda.	Soil Fertility Chemist, Uganda.
Feltham, K.S. Government Chemist, Northern Region, Nigeria.	Federal Government Chemist, Federation of Nigeria.
Rogerson, A. Scientific Officer, East African Veterinary Research Organisation	Senior Scientific Officer, East African Veterinary Research Organisation.
Logan, W.E.M. Deputy Chief Conservator of Forests, Tanganyika.	Deputy Chief Conservator of Forests, Uganda.
Butler, R.W., B.V.Sc. Veterinary Officer, Tanganyika.	Veterinary Research Officer, Tanganyika.
Orhan, A., M.R.C.V.S. Veterinary Officer, Class I, Cyprus	Chief Veterinary Officer, Cyprus.
Brunt, A.A.	Plant Pathologist, Virologist, West African Cacao Research Institute, Ghana. (first appointment)
Parmiter, J.P.	Agricultural Officer, Zanzibar. (first appointment)
Tinsley, T.W., B.Sc.	Deputy Director, West African Cacao Research Institute, Ibadan, Federation of Nigeria. (first appointment)
Rowe, R.D.H.	Assistant Conservator of Forests, Kenya. (first appointment)
Jones-Davies, W.J., B.V.Sc., M.R.C.V.S.	Veterinary Officer, Northern Rhodesia. (first appointment)
Balashor, Dr. V.	Physicist/Chemist, Northern Rhodesia. (first appointment.)

57/28 ROTHAMSTED EXPERIMENTAL STATION. RESEARCH FOR COLONIAL PESTICIDES COMMITTEE. ANNUAL REPORT 1956-57.

Evaporation of Deposits under Standard Conditions

A wind tunnel has been constructed, in which the rate of evaporation of deposits on glass plates can be measured in a current of air of known velocity. The tunnel is 2ft. long and of square cross-section, the area being 1 sq. ft. Air is drawn through it by a 12" aerial flow ventilating fan. The glass plates are carried in a rack so constructed that the plates are held accurately parallel to one another and to the direction of flow of the air. The rack is designed so as to offer minimum possible obstruction to the air-flow. The air-flow in the tunnel is made laminar by three honeycomb grids of plastic impregnated paper, one immediately behind the fan and two spaced a few inches apart up-wind of the plate-rack. The wind-tunnel is kept in a ventilated constant-temperature room at 24.5 ± 1°C.

The uniformity of rate of evaporation among the positions on the plate rack was tested by spraying a batch of plates, analysing several to obtain the initial deposit level, then filling the 15 positions with sprayed plates and determining the amount of insecticide lost after a period of exposure in the wind-tunnel by analysing each plate. Within the limits of experimental error, the amount lost by a plate was constant irrespective of the position in the plate-rack.

Gunther has found that the decay of insecticide residues on crops is logarithmic, so that the proportion of a deposit remaining is an exponential function of time. The form of the decay curve in the wind tunnel was determined as follows: a number of plates were sprayed with the same DDT formulation and were exposed in the wind-tunnel for different periods. The deposit density was determined on unexposed and also on the exposed plates by analysis. We have found, using deposits from both emulsions and suspensions of DDT, that the decay is linear with time during the greater part of the deposit. When about three-quarters of the original deposit has gone, the rate of loss becomes less and the curve of deposit against time "tails off". Table I shows the rate of loss of deposit from plates sprayed with different concentrations of DDT emulsion, during the initial linear period of evaporation. Within the limits of experimental error, the rate of evaporation is independent of the amount of DDT in the deposit.

The wind-tunnel has been used to measure the rate of loss of DDT from deposits produced by spraying a variety of DDT formulations. The time of exposure was such as to give a loss of about 50% of the DDT from plates sprayed at the same rate with the standard emulsion. The formulations tested were crude DDT emulsion, DDT crystalline suspension, and DDT emulsions modified by various additives to alter the crystal form. Plain and wax-coated glass plates were used. None of the deposits tested evaporated appreciably more slowly than the deposit from standard emulsion. Two resins tested as additives caused a significant increase in the rate of loss of DDT; these were Arochlor 5460 at 0.1% and 0.01%, and Coumarone-Indene resin at 0.05%, both in 0.1% DDT emulsion. The effect of the Coumarone resin was negligible at 0.01%. This effect of resins could be due to the inhibition of crystallization of the DDT, as super-saturated droplets would have a higher vapour pressure than DDT crystals.

The difference between our findings with DDT emulsions and those of Gunther mentioned above may be due to other factors than evaporation which operate in the field to reduce deposit levels. In particular, crop growth would be expected to result in an exponential decay of the insecticide residue level. Irregularity of the deposit under field conditions would also result in a falling off in rate of loss with time, as the area of the deposit would be progressively reduced by the loss of the lightly sprayed portions.

TABLE I

Initial deposit γ/cm^2	Period of exposure hours	Rate of loss γ/cm^2 per day
0.15	6	0.30
0.31	9	0.35
0.63	24	0.30
1.35	48	0.30
2.8	96	0.34
5.3	168	0.31

Contact Toxicity of Deposits to Houseflies

Flies are anaesthetized and placed in a perspex cell, the floor of which is a glass plate. The dimensions of the cell are such that the flies can walk but cannot turn over; they are therefore compelled to walk on the glass plate. When the flies have recovered from the anaesthetic, the glass plate is slid out of the cell and another, bearing the deposit to be tested, is simultaneously slid in. After exposure, the glass plate is replaced with a clean one, and the flies are anaesthetized and returned to their cages. The process of sliding in one plate to take the place of another takes about 5 to 10 sec. Exposure periods of 1 to 5 minutes have been used successfully.

The mortality caused by a given deposit depends on the gap between the surface of the plate and the lid of the cell. If the gap is small, the flies are pressed down on to the deposit and the mortality is increased. The upper limit for the gap size is determined by the point at which the flies are able to turn over, and so avoid walking on the deposit.

The technique can be used to assess the contact toxicity of deposits on glass plates, either plain or wax-coated to simulate leaves, but it will require modification before it can be used with deposits on leaves themselves as the irregular surface of the leaf would make it impossible to work with a predetermined gap between deposit and cell lid.

57/29 IMPERIAL COLLEGE. RESEARCH FOR COLONIAL PESTICIDES COMMITTEE. ANNUAL REPORT 1957.

Two promising new variations in olfactometric technique are described.

Brief Olfactory Stimuli

A flying insect in the field, may first encounter an olfactory stimulant in drifts or eddy currents at some distance from the source, and thus the first stimuli may be of short duration. The effects of transient stimuli are therefore being investigated. Brief pulses of odorous vapour of known concentration are injected into the air flowing over an insect in a small wind tunnel. The duration of the pulse and consentration of vapour are varied and the resultant activity of the insect noted. A preliminary indication is that response threshold may vary with pulse duration e.g. ethyl acetate at 3 x 10-4 molar concentration was observed to activate a blowfly when the pulse persisted for about 0.5 seconds but failed to do so when the pulse lasted only about 0.05 seconds. Also the intensity of reaction of a fly exposed to short pulses of a repellent vapour appears to vary with the concentration. The initial speed of a reacting fly is measured by enclosing the fly in a small freely rotating cage, the movements of which can be monitored by a photo-electric device.

Prolonged Olfactory Stimuli

A simplified choice-chamber instrument has been constructed which will facilitate the rapid assessment of the attractive or repellent properties of mixtures of organic compounds in the year ahead.

Air is drawn in streamline flow by means of a conical wind tunnel, through a perforated partition into an opposed narrow insect cage about 6" in diameter. The partition incorporates four removable perforated discs from which stimulant evaporates at a constant rate into the airstream; the rate of evaporation of a formulation may be varied by partially masking discs with a varnish. The use of such discs to provide controlled concentrations of vapour is a considerable simplification of the previous method which involved the use of multiple saturator and mixer circuits. In preliminary tests with cetyl alcohol and isovaleric acid, the responses of blowflies and tsetse flies were in agreement with expectations.

Mode of Action of Insecticides

Experiments are in progress on the absorption of an oil by blowflies and its subsequent translocation in the tissues in the presence or absence of an emulsifying agent. The oil used is hexadecane containing 1 per cent hexadecene, in which radioactive iodine can be incorporated to permit the detection of very small quantities.

57/30 UNIVERSITY OF BRISTOL. LONG ASHTON RESEARCH STATION ANNUAL REPORT 1956-57.

Crop Spraying

Leaf Spot Disease of Lacatan Bananas

The investigations on the control of Leaf Spot Disease (Mycosphaerella musicola) on Lacatan Bananas by means of copper fungicides, commenced in 1952, were brought to a satisfactory conclusion. It was shown that Lacatan bananas in Jamaica are particularly subject to infection by ascospores. A control is obtained by the application at two week intervals of copper fungicides to the undersides of the two freshly opened top leaves. It is essential to obtain complete coverage of the vulnerable leaves and this can only be achieved by the addition of highly efficient wetters to the sprays. Nonyl disodium sulpho-succinate applied at not less than .0125 per cent proved the most effective wetter. However, this ionic wetter could not be used with Bordeaux Mixture. Of the non-ionic wetter suitable for use with Bordeaux, alkyl aryl polyether alcohol at 0.025 per cent was satisfactory. The spray deposits obtained with this wetter were investigated comprehensively and reported.

The results of this investigation made it necessary to revise the technique of spraying in Jamaica. The standard method of 'mist application' of all the leaves was changed to full coverage forceful spraying of the undersides of only the top two leaves at each fortnightly application. Special lances, trigger taps and nozzles were designed for this type of spraying.

Spray Deposits on Arabica Coffee

A preliminary survey was carried out at the Coffee Research and Experimental Station, Lyamunga, Tanganyika to determine (a) a technique of spraying coffee leaves under precise laboratory conditions for a study of spray deposits and (b) to ascertain the influence of detergents on the distribution of copper fungicides. The assays of the deposits showed considerable differences to those obtained on banana leaves. The survey showed that further work would give valuable data of considerable importance for the efficient spraying of coffee.

Equipment

Centrifugal Power Spray Pump

Small power (80 c.c. and 34 c.c. T.C. engined) spray machines designed for use in the tropics for a wide range of duties were described in the 1954 Annual Report Long Ashton Research Station. The design of the 80 c.c. machine has been considerably simplified by the commercial development of a centrifugal pump. The machine is now extremely reliable and well suited for hard usage by unskilled labour. It has many uses in the tropics when used with suitable spray lances.

Long Ashton $\frac{1}{4}$" B.S.P. Spray Nozzle

The utility of the nozzle has been considerably increased by modification and additions of particular interest for use in the tropics, for example mosquito spraying, aircraft spraying, mist blowers, row crop spraying, etc. A $\frac{1}{4}$" B.S.P.M. thread is used for the nozzle body; this dimension makes manufacture cheap yet it is sufficiently robust. By a simple interchange of parts swirl and fan spray patterns are available with a wide range of throughputs and droplet sizes. The fan spray consists of a protected ceramic that is easily aligned and cleaned. The nozzle is used in connection with a filter unit.

Compressed Air Spray Equipment

A small reciprocating compressor driven by a 70 c.c. 2-stroke T.C. engine was assembled for small scale experiments on coconuts in the British Solomon Isles. The compressed air operates a small spray pistol, so that small discrete droplets of insecticides can be applied to coconut spadices. The equipment makes it possible to simulate the application of droplets by large 'mist blower' sprayers. The compressor is operated on the ground and the compressed air carried by hose to the top of an observation ladder.

Light Weight Spray Lance

A light weight spray lance with a new type of trigger tap has been designed for numerous duties, for example mosquito control, tobacco spraying etc.

57/31 WESTERN SOKOTO MALARIA CONTROL PILOT PROJECT ANNUAL REPORT, MARCH 1957

Persistence of Insecticides on Mud Surfaces

An experiment designed to evaluate the effect of humidity on residual insecticides sprayed on mud walls has commenced. Three series of eight 12 x 18 x 2" mud blocks have been made using a red mud from Birnin Kebbi, a grey mud from Argungu (both these towns are in Western Sokoto) and a brown mud from Yaba (near Lagos). These blocks are being stored in a corner of an unsprayed grain store in Kano. The climate of Kano is similar to that of Western Sokoto but the ease of access and facilities are better than at Birnin Kebbi. A similar series of mud blocks are being constructed in Lagos where they will be stored under humid conditions.

An endless belt machine is being constructed by the Nigerian Railway Corporation which, driven by a constant speed motor, will enable reproducible dosages of the insecticides to be obtained.

When this is delivered the blocks will be sprayed and chemical follow-up will be performed in conjunction with the bio-assay techniques.

Surface Sampling Methods

A new method for sampling insecticide deposits on mud surfaces has been evolved. It is similar to the Barlow adhesive tape technique but uses as the adhesive a water soluble gum which is insoluble in acetone and hydrocarbon solvents. In the Barlow technique the adhesive was soluble in these solvents, which are used to extract the insecticide, and interference in some analytical techniques occurred. However using a gum which is insoluble in these solvents no interference occurs.

A solution of the gum containing 2 parts by weight of gum to one part by weight of water is spread thinly on a known area of non-absorbent paper. When the gum is on the point of setting the paper is pressed firmly to the surface and, when the gum has dried, removed. The insecticide is extracted by washing with suitable solvents.

A series of results showing the recoveries of the gum, Barlow, and Alessandrini parchment paper techniques are shown in the table. The dosage of the insecticide was 240 ± 30 mg/ft^2 of technical DDT and the areas sampled in each case 1/12 ft^2.

Sample Method	Barlow				Gum method						Alessandrini		
	1	2	3	mean	1	2	3	4	5	mean	1	2	mean
DDT mg/ft^2	265	196	258	240	255	241	284	233	207	244	192	160	171

These preliminary results show that the Barlow and Gum methods give results in good agreement. The results from the Alessandrini method are insufficient to make conclusions.

Persistence of DDT on Mud and Other Surfaces

The report that the DDT inactivating properties of muds were due to the presence of micro particles of the mud has been confirmed. A sample of mud from Yaba was wet sieved using B.S. 410/43 test sieves and divided into five particle size fractions. The sorptive power of each fraction for carbon tetrachloride was determined by Hadaway and Barlow's method.

In addition the three largest particle size fractions were ground in a ball mill to pass the lowest particle size sieve and their adsorptive capacities redetermined. Small blocks were made from the fractions and after drying out for three weeks were sprayed at 203 mg/ft^2 of technical DDT with a 75% DDT water-dispersible powder. Four weeks after spraying the surfaces were bioassayed using *Aedes aegypti* females and the time for 100% knock down obtained. The results are shown in the table.

Particle size range (microns)	Per cent of normal mud	Adsorptive capacity per cent	Adsorptive capacity after grinding	Time to 100% KD (hours)	Reciprocal KD x 100 (persistence)
Normal mud	100	14.8	-	1.25	80
Above 442	14	0.3	2.1	-	-
442 - 251	9	0.4	2.7	-	-
251 - 104	18	0.0	2.8	1.6	63
104 - 66	26	11.1	-	3.4	29
Below 66	33	27.8	-	4.0	25

Other artificial surfaces were prepared and sprayed at the same time with the same dosage of DDT. All the materials were passed through the 66 micron sieve.

Material or Mud	Adsorptive Capacity %	Time to 100% KD (Hrs)	Reciprocal KD x 100 (persistence)
Birnin Kebbi	19.8	3.4	29
Argungu	14.1	2.8	36
Silica Gel	48.6	1.0	100
Kieselguhr	0.0	2.0	50
Alumina	-	3.5	29
Kaolin	2.9	1.0	100

During the four week period after spraying the mean minimum temperature was 77°F and the mean maximum 86°F. The mean relative humidity at 10 a.m. was 79% and at 4 p.m. 74%.

The results show that the adsorption of DDT is caused by the presence of particles in the mud below 100 microns in diameter. However the small particle size is not the main criterion since if the large particle size fraction is ground to the same size as the naturally occurring fine particle size, no appreciable increase in the adsorption occurs. The reason for the longer persistence on the normal unsieved mud may be due to the presence of DDT on the large diameter non-adsorptive particles in the surface.

In the second series of surfaces, the lack of adsorption of DDT on silica gel is surprising. The bioassay of this block has been repeated several times with the same result. The cause may be due to the high relative humidity producing saturation of all the adsorption sites with water vapour. The high adsorption of alumina is noteworthy as Western Sokoto muds contain approximately 10% alumina.

These results appear to indicate that the adsorption phenomenon is due to the spatial structure of the clay lattice and not necessarily to the chemical composition, although the two will be related.

57/32 BITING FLY RESEARCH PROJECT, ENTEBBE, UGANDA, ANNUAL REPORT 1956-57.

Laboratory Investigations

A laboratory colony of S. calcitrans has been established and maintained at a strength of approximately 2000 adults. The hatching rate for segregated batches of pupae was found to vary between 62.8% and 17.7% with an average of 35.3%. To test whether this low rate might be due to starvation during the larval stages as a result of overcrowding, pupae were bred out from two identical batches of media. Whilst 200 eggs were introduced into the first double this number were placed in the second. The corresponding weights of 100 pupae, subsequently recovered, viz. 0.89 and 0.42 gms, confirm the effect of overcrowding. Considerable variation, both hourly and daily, was observed in the frequency of oviposition but two maxima were definable between 8 and 9 a.m. and between 2 and 3 p.m. Egg laying appeared to be at a minimum about midday. Five stages in the development of the larvae have been recorded for identification purposes. Present methods of observation requiring continuous hourly inspections (night and day over 10 days) are onerous and it is hoped to devise a quick drying amyl acetate painting technique to facilitate these studies, Experiments are also planned to investigate the effect of temperature and humidity on the life cycle, egg laying activities and behaviour of the fly; also to determine MLD values for various insecticides against adults and larvae.

Transmission of *T. congolense*

The passaging of *T. congolense* through rats has been continued. Despite nearly 500 attempts to transmit the parasite mechanically using laboratory bred and infected *S. calcitrans*, results were negative. It is now thought possible that other species of biting fly (*Tabanidae*), widely distributed in Uganda, may be responsible for the mechanical transmission of animal trypanosomiasis. *Haematopota brucei*, for example, is common to the whole of the Protectorate.

Field Investigations

A number of field observations relating to the bionomics of *S. calcitrans* have been collected in various parts of the territory including N. Busoga, Tororo, Kitalya and Kawanda. At H.M. Prison Farm, Kitalya it was noted that cattle were particularly worried by flies at evening milking time. *S. nigra* adults were seen in the milking shed and pupae were taken from vegetable refuse near an old disused cowshed. Numerous *Stomoxys* were found on cattle in the nearby native kraals. Few *S. calcitrans* adults were apparent on the sites visited. Larvae and pupae collected outside a cattleshed at Kawanda Agricultural Research Station were thought to be *Stomoxys* spp. Some *S. calcitrans* larvae were found near the calf shed at Namulonga Cotton Growing Corporation Research Station., Only one *S. calcitrans* was obtained near Nagongera, W. Budana, from ground grossly contaminated with old and new dung, where two small herds of cattle were tethered. Several herds of cattle were visited in the vicinity of Lubale and adult flies were collected from one small group of cattle near Ntungamo where numerous biting flies were reported in the wet season. It is tentatively concluded as a result of field investigations, that *Stomoxys* breeding does not occur to any large extent in dung or manure heaps but takes place in rotting vegetation which probably must be contaminated with waste products.

A permanent camp is being erected at Bukomero in order that ecological, population and behaviouristic studies can be carried out. This site was chosen having regard to the following requirements.

1. Within 100 miles radius of Entebbe
2. Heavily infested for the greater part of the year.
3. Glossina spp. absent.
4. Numerous head of cattle present.
5. Little or no African cultivation of habitation.
6. Reasonable accessibility within the area.

57/33 COCONUT PEST RESEARCH ZANZIBAR. INTERIM REPORT OCTOBER 1956 - MARCH 1957.

F. L. VANDERPLANK, Entomologist.

This report summarises the work undertaken to control Pseudotheraptus wayi on the 100 acre experimental plot at Kidichi/Mdo. Reference is made to the difficulties which confronted the experimenter and how these were overcome. The effectiveness of treatment is noted by comparison with the control plot at Dole/Mdo in terms of the average number of neanides found and the V.D.R. (Vidaka 1) Damage Rate).

The insecticide used was 10 DRDK formulation2). At first it was applied at 1½ galls per acre but later this could be reduced to 1 gall/acre. It was necessary to spray every 2 or 3 months to counteract reinfestation from invading Ps.wayi and to protect new inflorescences.

The lower rate was adopted following trials with the Long Ashton Mist Blower equipped with a rotary atomiser devised by the entomologist. About 90% by volume of the insecticide was present in particles between 70 and 90 microns diameter.

It is indicated that effective, economical control, resulting in over 95% kill of Ps.wayi can thus be obtained.

Notes:

(1) Vidaka: Kiswahili term for the coconut flower buds, flowers and young nuts up to two months after fertilization.

(2) 10 DRDK formulation: This consist of 8%-10% pp' DDT with 1% Epok Coumarone Indene Resin, Grade C 469, dissolved in 50% Diesolene/50% Power Kerosene.

57/34 COLONIAL PESTICIDES RESEARCH UNIT, ARUSHA, TANGANYIKA ANNUAL REPORT 1956-57.

Tsetse

The Galapo block was largely cut down in July/August 1956 and observations have been discontinued. This experiment has now run for $5\frac{1}{2}$ years and during the whole of this time the apparent densities on the hillside control have been about 300 times those in the treated block.

A further site of approximately 24 sq. miles near Chungai in the Central Province of Tanganyika is being surveyed as a preliminary to future field experiments. It is anticipated that selective spraying of resting sites (Kabiganda Valley) will commence in the near future.

Mosquitoes

1. Taveta-Pare: Spray Assessment

The second spraying cycle was completed in June 1956, and the third cycle in March 1957. The malaria parasite rate in young children and the vector mosquito house catches are now both very low. The outside resting population of *A. gambiae* is however still considerable although there is some suggestion that the individual life span is reduced. There is as yet no evidence of any resistance to dieldrin developing and it is now eighteen months after the first application of insecticides.

During the 1956-1957 spraying cycle for malaria control at Nandi, Kenya, and in the Taveta-Pare district of Tanganyika, the sample paper technique, established during the last two spraying cycles, was used to give an estimate of dieldrin deposit in houses. Again the house-to-house distribution of insecticide was positively skewed. The Taveta-Pare estimates were normalised by a logarithmic transformation, when the Bartlett test showed that the variances for individual spray teams differed significantly.

The sample paper technique is suspect because the papers aan easily be deliberately overdosed. The technique was investigated by comparing sample paper deposits with the dieldrin content of wall scrapings in ten houses in the Taveta district. The best available spray team treated all the houses which were sampled. The analysis results are shown overleaf.

The mean deposit estimates obtained by sampling method 1 and 2 are not significantly different. The variance of the estimates from method 1 is significantly less than the variance of the estimates from method 2, indicating either that sampling by scraping gives inherently more variable estimates than sample papers, or that the spray operator sprayed the papers more carefully than the rest of the walls. The sellotape sampling technique has been shown to be unsuitable for the type of house encountered in the Taveta-Pare area. Thus, of the available sampling methods, sample papers appear to give the best estimate of dieldrin deposits in houses, provided that the spraying is adequately supervised.

Method of deposit estimation	Mean deposit gm/sq.m.	Standard deviation
1. Sample papers	0.35	0.067
2. Wall scrapings	0.35	0.173
3. Expected nozzle dosages	0.41	0.055

2. Western Sokoto: Dieldrin Resistance in A.gambiae

The survey of the Pilot Project and the Extension zone of the Western Sokoto Malaria Control Project was completed in October, 1956. An equal degree of dieldrin resistance with a linked BHC resistance was found in both the dieldrin and gamma BHC treated areas although one area had been treated for two months only. There was no indication of DDT resistance. The survey was then extended to include Sokoto and Kano city. Neither of these areas had had any extensive control schemes, yet dieldrin resistant A.gambiae were found in both places.

After completing this work in Northern Nigeria the survey was extended to S. Nigeria. The search for resistance in A.gambiae was extended to include Yaba district and the town of Ilaro 40 miles to the North West where a Malaria control scheme using BHC had been carried out from 1949 to 1953. There was no indication of resistance in either of these districts.

3. Dar-es-Salaam: Application of Granular Insecticides

During April-June 1956, an attempt was made at Dar-es-Salaam to prevent the seasonal increase in anopheline populations that accompanies the long rains. Using a Cessna aircraft, granules containing 2% (w/w) of dieldrin were applied at a rate of 1 lb per acre to the large seasonal breeding sites near and within the township. About 5,000 acres were treated 7 times during a period of approximately nine weeks, and 17 tons of granules were applied. The experiment was the co-operative effort of this unit, the East Africa Institute of Malaria and Vector Borne Diseases, the Medical Department, Tanganyika and the Medical Officer of Health, Dar-es-Salaam.

No appreciable breeding of anopheline could be found in the treated sites. The results from the house catches of mosquitoes are not unequivocal, partly because the year was one of a typical rainfall and also because of the difficulty of distinguishing the effects of the various methods of control in the area, but there was certainly a pronounced fall, and not the usual seasonal peak in the adult anopheline populations, and extremely low catches were obtained during the rest of the year. Unfortunately it was not possible to obtain reliable records of parasitism; those that were taken did not indicate any obvious change as a result of the great reduction in vector population.

4. Mto wa Mbu: Field Trial of New Dieldrin Formulation

Preliminary investigations have been made into the possibility of carrying out a field trial of the new dieldrin formulation, in conjunction with the Tanganyika Medical Department at Mto wa Mbu, an isolated settlement of about 3,000 people at the foot of the rift wall in Masailand. A survey in February 1957 showed an average of 80 A.gambiae and 20 A.funestus per house, throughout the settled area, with sporozoite rates of 3% and 6% respectively. A house survey is at present in progress, and samples of the soils which are used for plastering in the area have been sent to England for "sorption" tests.

5. Magugu: Hut Experiments

Five experimental trap huts of a new type designed to exclude ants have been erected at Magugu about 90 miles south of Arusha. Two have been plastered with a red very actively absorbent mud and two with a grey mud not so actively absorbent. One of each type was sprayed on 16th January 1957 to give a low dosage (about 0.15 grams per square metre actually on the wall) of standard dieldrin wettable powder and the other of each type was similarly sprayed with a dieldrin wettable powder formulated to prevent sorption by active muds. During the first six weeks all four huts gave practically a 100% kill of *A.gambiae* entering.

Cotton Pests

The experimental cotton at Urambo was very heavily attacked, first by American bollworm, *Heliothis armigera*, and secondly, later in the season, by stainer, *Calidea dregei*. Either pest alone was sufficient to ruin the crop completely. It was found that these pests could be successfully controlled by insecticides, the best treatment being weekly sprays of DDT at one pound per acre, with the addition of BHC at ¼ pound per acre, when necessary, for Aphis control. Twelve weekly sprays were needed to cover the full period of insect attack. Where the cotton was well grown and the pests controlled, yields were approximately 1,500 pounds of seed cotton per acre. At present prices, even with the heavy use of insecticides necessary, this should be profitable, particularly for the African grower.

Investigations on the persistence of DDT and endrin on cotton are reported in PANS Vol. 3 No. 1. p.12.

Unirrigated cotton at Mananga is attacked by red bollworm (*Diparopsis castanea*), American bollworm (*Heliothis armigera*), spiny bollworm (*Earias* sp.) aphids, cotton stainers and red spider. Of these pests red bollworm is the most serious both because it is the most common numerically and because previous attempts at the insecticidal control have not been very successful.

Maize Stalk Borer

Trials this season have been laid at Mbulu, Northern Province, to investigate various methods of improving control and to study a number of the problems that arose last year. Conditions have been unsatisfactory as rainfall has been so distributed that stalk borer emergence started before maize could be planted. A heavy outbreak of Armyworm (*Laphygma* sp.) destroyed part of the trial and then heavy rain fell during the applications of insecticides. Heavier dosage rates were required this year because of the rains. There is little difference between dust and spray at equivalent rates, but endrin has proved more effective than either DDT, gamma BHC or malathion. It is considered that for efficient control, accurate application is as important as choice of insecticide or formulation1

Other indications are that, under these infestation conditions, a single application of DDT emulsion at a high rate is slightly more effective than two at a lower rate; that malathion is less effective than DDT; and that a deposit of endrin on the stalks only is less effective than spraying the whole plant, but reduces the infestation by half. Efforts to improve the persistence of a deposit with various resins do not appear to have had any practical success.

The relationship between infestation by maize stalk borer and yield has been studied and found to be linear up to 50% infestation. It is also considered that the loss caused by infestation is proportional to the potential yield of the uninfested crop. Observations have continued on the relationship between rainfall and the incidence of stalk borer in areas of different rainfall regimes. The rainfall distribution appears to be the major factor in determining the time and degree of infestation, and hence the amount of insecticidal control required.

Other Agricultural Pests

Experiments with seed dressings on beans have demonstrated the possibility of controlling the bean fly, Agromyza (Melanagramyza) phaseoli. Dressing the seeds with small quantities of insecticide emulsifiable concentrates depressed germination to some extent but showed very clearly that aldrin, endrin and dieldrin were effective in completely preventing attack for four weeks after germination. The rate of dressing was such that approximately 0.2 lbs of active ingredient were supplied to each 100 lbs of seed. Wettable powders or formulated seed dressing of aldrin and gamma BHC, as dry dressings, gave complete protection for four weeks after germination. Parathion, Dipterex (Bayer compound 4519), diazinon and DDT were less effective. Because of drought no yields could be taken.

In the Northern Province of Tanganyika coffee trees are sprayed with DDT to give protection against Antestiopsis lineaticollis. Stal. An experiment was undertaken at the Coffee Research Station, Lyamungu to determine the distribution of a DDT emulsifiable concentrate which was applied with the Pest Control Spraymaster. The insecticide was applied to well-foliated mature coffee trees at the rate of 1.4 lbs per acre. The top and bottom halves of twenty trees were sampled separately each sample consisting of twenty to thirty randomly selected leaves. One vertical and one horizontal sample paper was placed as near as possible to each tree that was sampled. The mean deposit of 36 mg.per sq. metre on the top leaves was significantly less than that of 47 mg. per sq. metre on the bottom leaves. A correlation exists between the deposits on the bottom leaves and the vertical papers.

A persistence study of the DDT residue on the leaves is still in progress. The persistence of deposits on the tops and bottoms of trees in a shaded and an unshaded plot are being compared. During the first week after spraying, the four deposit degradation curves are similar to that obtained for cotton at Urambo in 1956 and degradation takes place more slowly after one week has elapsed. The details of this work will be reported at a future date.

Larvae of Cerambycid borers are known to cause considerable damage to kapok and citrus, and a survey of the problem has been carried out in the Tanga district. The serious pest of kapok, Tragiscoschema nigroscriptum has been found there.

A small infestation of the sugar cane borer, Eldana saccharina near Arusha is being observed as a possible danger to the sugar industry.

The local rice crop is attacked by a leaf beetle, Trichispa sericea, and two stalk borers, a moth Ampycodes pallidicosta and a Diopsid fly.

57/35 COLONIAL PESTICIDES RESEARCH UNIT, PORTON, ANNUAL REPORT 1956-57.

Susceptibility of Mosquito Larvae to Insecticides

With the development of resistance to insecticides by mosquitoes in many parts of the world, the need for standardised tests of susceptibility has become imperative. Much of the basic information needed for formulating satisfactory tests for mosquito larvae, however, is lacking. Investigations have therefore been carried out, the object of which, in addition to providing information of intrinsic interest on the variations in susceptibility of normal mosquito larvae under different conditions, has been to contribute towards filling this gap. Up to the present, work has been concentrated on larvae of Aedes aegypti because of the comparative ease of rearing them, and because their response to insecticidal treatment can be accurately assessed by measuring the strength of their photonegative reaction to a beam of light.

Results of experiments conducted into the effect of age on the susceptibility of mosquito larvae are reviewed. Third instar larvae are considered most satisfactory for use in susceptibility tests as specified. (An account of this work is given under 57/39 page 162).

Following a recent claim that the mortality of Anopheles quadrimaculatus larvae is greatly affected by the concentration of alcohol or acetone used to make up DDT solutions, experiments have been carried out to determine whether variation in the concentration of acetone affects A.aegypti larvae in this way. Results so far obtained strongly indicate that a tenfold variation in acetone concentration produces no significant effect on the mortality of larvae of any age.

Another supplementary investigation is being carried out into the effect of varying the density of larvae in the insecticidal solution. Preliminary results indicate that this factor has an important influence on mortality, and that more attention needs to be paid towards standardising it in larval susceptibility tests.

Sorption of Insecticides by Soils

Further various aspects of this subject are reported.

1. Repeated sprayings of insecticide on active soils do not affect the sorption rate of fresh applications. Successive monthly applications of DDT and dieldrin on to blocks of Uganda mud at 100 mg/sq. ft. were sorbed at about the same rate.

2. No significant loss in effectiveness of insecticide, sprayed on active soils, is attributed to chemical decomposition. Lindane, dieldrin and DDT have been recovered after sorption. There was no evidence for decomposition of dieldrin after 12 months in the sorbed state.

3. Increases in temperature accelerate the sorption of DDT and dieldrin and the diffusion inwards of dieldrin after sorption. The diffusion rate of DDT is only slightly affected. The influence of relative humidity upon the sorption of insecticides has now been shown to apply also to other soils. These soils covered a wide range of activity but on all of them the rates of disappearance of insecticides were much greater at 10 than at 90 per cent humidity. At either humidity the same sequence of activity of the range of soils used was maintained, but, whereas at 10 per cent humidity DDT and dieldrin disappeared from all the soils in a few days, at 90 per cent the only deposits to be completely sorbed in three weeks were those of dieldrin on very active soils.

4. Previous attempts to prevent sorption by spray additives have not been successful. A new commercial wettable powder formulation of dieldrin has been devised, which has a much better residual action on active soils that the standard wettable powder. This has been confirmed by biological tests with mosquitoes using both a culicine, A.aegypti and an anopheline A.stephensi.

5. Two methods for removing surface deposits from sprayed walls have been suggested and a comparison of the recoveries obtained has now been made. One uses adhesive-tape and the other paper covered with a thin layer of silicone grease. The tape recovers a higher percentage of freshly-sprayed insecticide than the paper and this simplifies interpretation of the results. Both will give an indication that sorption is occurring but both suffer from various disadvantages and there is still a need for better methods of sampling surface deposits.

Persistence of Insecticides on Various Materials

A preliminary determination has been made of the residual properties of DDT and dieldrin on some surfaces other than dry soils which are used in house construction. (Further details are reported under 57/40, page 164).

Environmental Conditions

Environmental conditions, especially atmospheric humidity, have been shown to affect the distribution, and therefore, the availability, of insecticides sorbed by some dried soils. It has also been shown that the effectiveness of a given dosage of insecticide is influenced by the post-treatment temperature.

Investigations of the effect of pre-treatment temperature on susceptibility of insects to insecticides necessitated studying age, sex and feeding factors. Details of these investigations are to be found as follows:

Effects of age, sex and feeding on the susceptibility of insects to insecticides. (57/36, page 159).
Effects of temperature during the pre-treatment periods. (57/38, page 162).

Organic Phosphorus Insecticides

The development of strains of mosquitoes and houseflies resistant to chlorinated hydrocarbon insecticides has intensified the interest shown in the insecticidal properties of other groups of chemicals, especially organic phosphorus compounds. A number of phosphorus insecticides with a comparatively low degree of mammalian toxicity have become available, and the relative toxicities of three of them to houseflies and some mosquito species have been determined.

The insecticides used were diazinon, Chlorthion and malathion in kerosene solutions. Medium lethal doses for female houseflies were 0.077, 0.33 and 0.77 µg. per fly respectively. Relative toxicities to mosquitoes varied considerably from one species to another. Thus, Chlorthion was more toxic than diazinon to two culicines, *Aedes aegypti* and *Culex molestus*, whereas diazinon was more toxic than Chlorthion to two anopheline, *A.stephensi* and *A.quadrimaculatus*.

It has previously been shown that some organic phosphorus insecticides vary greatly in their order of effectiveness against different species of mosquitoes. This may be due to various causes such as differences in degree of penetration, metabolism and excretion or to differences in the enzymes which are inhibited in the mosquitoes. The changes in susceptibility from one mosquito to another are sufficiently striking as to suggest that an investigation of their causes may yield some clues about the mode of action of these insecticides in mosquitoes.

Initial experiments showed that *A.aegypti* and *A.stephensi* both contained a potent non-specific esterase system. The latter, on a weight basis, yielded extracts which were about four times as effective as those from *A.aegypti*. Males and females of both species were equally active and the same esterase appeared to be generally distributed between head, thorax and abdomen. This esterase was inhibited after lethal doses of diazinon and Chlorthion had been given to the insects.

Only very low cholinesterase activity has so far been detected in mosquitoes but possibly natural inhibitors are present in the crude extracts which reduce in vitro activity.

Application of Molluscicides

Various ways have been explored in which molluscicides might be added to water at very slow, controlled rates sufficient to prevent re-infestation after most snails had been killed by an initial high dose. It is necessary that the method should be a simple one and the following have been tried.

(a) Briquettes made from a mixture of cement or plaster and the molluscicide. Their main disadvantage was that if the hardening properties of the carrier were not to be affected the percentage of molluscicide had to be kept low. This especially applied to an alkaline material like sodium pentachlorophenate.

(b) Pellets made from the molluscicide bound with a thermosetting resin. These were easily made and were stable in water but the leaching rate of the chemical was dependent upon the concentration left in the pellet and therefore decreased with time.

(c) Films of plastic separating the molluscicide from the water. These appear promising as their action in controlling leaching should be independent of concentration although the films so far tested have either been too porous or not porous enough.

Aerial Spraying Studies

Spray assessment methods. The efficiency of droplet collection of some isolated spheres and a cascade impactor have been measured in a wind tunnel, using droplets varying from 50 to 160 microns in diameter in wind ranging from 3 to 5 metres per second. The collection efficiences of spheres were found to be similar to those computed by Langmuir and Blodgett, and the collection efficiency of the cascade impactor was found to be 70 ± 10 per cent.

Similar wind tunnel studies on the collection efficiency of various materials used for sampling sprays (e.g. siliconed glass plates, magnesium oxide coated glass plates, and filter papers) are being made.

Westland S-51 Helicopter WB 810. The Westland S-51 has been undergoing repair and major overhaul at the manufacturer's works as a result of damage sustained in a forced landing whilst on a test flight, and consequently has been out of service during the period under review.

The spray apparatus was removed and overhauled in C.P.R.U. workshop in preparation for refitment to the aircraft when it returns to service.

Auster J5G Aircraft XJ 941. A new boom and nozzle type of equipment has been designed, manufactured and fitted to the aircraft in an attempt to obtain finer sprays of insecticide than were given by the standard Auster equipment. When the aircraft was flown at an airspeed of 70 m.p.h., and T.P. 5007 was sprayed at rates of 6-12 gallons per minute, the volume median diameter of the spray drops was of the order of 150 microns compared with that of 200 microns obtained under similar conditions with the standard Auster equipment.

The maximum spraying speed of the Auster being only 70 m.p.h. it is not possible to obtain any further reduction in drop size by utilising the shattering effect of the wind against the liquid emerging from the jets on a boom and nozzle system, neither can the pressure in the boom be substantially increased without recourse to a more complicated power supply independent of air speed, which in turn will considerably reduce the useful load of the aircraft.

By spraying with a rotary device such as a spinning disc or brush, it is possible to obtain smaller drops although the output will be comparatively small. To enable some of these types of apparatus to be assessed, a number of modifications have been incorporated in the Auster aircraft, The attachment points are located under the outer wing sections, the plumbing and controls have been arranged in such a manner that any of these devices and the booms previously used can be readily fitted or removed as required.

Rotary cage atomiser. A new type of rotary atomiser in the forms of a wire gauze cylinder has been produced for use on aircraft by Messrs. Britten-Norman. A pair of these atomisers mounted on the lower wing tips of a DH Tiger Moth have been tested and found to produce a spray of droplets having a VMD of 50 microns when spraying T.P.5007 at the rate of 6 gallons per minute at an aircraft speed of 65 knots.

57/36 EFFECTS OF AGE, SEX AND FEEDING ON THE SUSCEPTIBILITY OF MOSQUITOES TO INSECTICIDES.

A.B. HADAWAY and F. BARLOW. Colonial Pesticides Research Unit, Porton. Report No. 129.

Knowledge of any changes in the susceptibility to insecticides of mosquitoes with age was essential before other investigations could proceed, and this paper is concerned primarily with the toxicity of two insecticides to adult female Culicine and Anopheline mosquitoes of different ages. Moreover, mosquitoes, like other blood sucking insects, are intermittent feeders with fairly regular feeding cycles and are therefore suitable test insects for a study of the relationship between physiological and nutritional state and susceptibility to insecticides.

Topical applications of solutions of insecticides in kerosene were made to two species of mosquito, Aedes aegypti and Anopheles stephensi, which were reared and held before and after treatment at 25°C. Male A.stephensi were more susceptible to DDT than were females of the same age. The susceptibility to DDT of female A.aegypti fed on human blood was not significantly different from that of females fed on guinea pig blood.

There was a slight increase in the susceptibility to DDT of unfed female mosquitoes as they aged from 1-2 days to 2-3 days. Three hours after taking a blood-meal, when the body weight was more than double its original value owing to the presence of undigested blood in the stomach, the mosquitoes were only slightly less susceptible than unfed females of the same age, but when digestion had proceeded for 24 hours susceptibility had decreased considerably, and the median lethal dose of DDT had increased nearly twofold, e.g. from 0.016 . for unfed female A.aegypti 2-3 days old, to 0.030 24 hours after the blood meal. As the mosquitoes aged still further and as the products of digestion were utilized, largely in egg production, susceptibility increased to its original level. This cycle of events was repeated after each subsequent blood meal. Thus the susceptibility of both A. aegypti and A. stephensi to DDT fluctuated in a regular cycle, which could be correlated with the feeding-cycle and with the physiological state of the insects. Similar variations in susceptibility were obtained with dieldrin.

It is evident that when mosquitoes are used in biological assay their age and nutritional state should be strictly standardised. From the practical point of view, it is clear that female mosquitoes are most susceptible to DDT and dieldrin when they are searching for a blood meal and for a few hours after feeding, i.e. when they are most likely to come into contact with residual deposits in treated houses. It must be stressed, however, that this refers to innate susceptibility, and that the actual dosage of insecticide acquired by contact with a given deposit may vary with the nutritional state of the mosquito. For instance, unfed females tend to be more active than recently fed ones and greater activity usually leads to the pick-up of higher dosages. On the other hand, the distended abdomen of a recently fed mosquito is more likely to come into contact with a deposit than is the thin abdomen of a hungry mosquito, although this applies more to the Culicine than the Anopheline mosquito. It may be noted that in preliminary tests with adult A. aegypti exposed to dry deposits of a DDT wettable powder on filter paper, kills of females exposed 24 hours after feeding were much lower than those of unfed or recently fed mosquitoes.

57/37 THE INFLUENCE OF TEMPERATURE AND HUMIDITY UPON THE ACTION OF INSECTICIDES. PART I: DURING THE POST-TREATMENT PERIOD, (Authors' Summary).

A.B. HADAWAY and F. BARLOW. Colonial Pesticides Research Unit, Porton, Report No. 117.

It is well known that the physical state of an insecticide may have a considerable influence on its effectiveness against an insect. It is also known that the toxicity of a given formulation of an insecticide may vary under different environmental conditions. Potter and Gillham showed that the temperature at which flour beetles (Tribolium castaneum) were kept after spraying had a marked effect on the toxicity of some contact insecticides. Since then, numerous workers have shown that the temperature during and after treatment, is an important factor in determining the toxicity of synthetic contact insecticides. There is evidence, too, from the field that the effectiveness of a given treatment may vary from one season to another. For example, Bordas and Navarro, and Burnett report that mortality rates of adult mosquitoes in houses sprayed with a residual insecticide increased in the wet season.

The relationship between environmental conditions and the toxicity of insecticides is complex because atmospheric conditions may affect both the insect and the insecticide. Thus, conditions during breeding and before treatment may influence the susceptibility of insects to insecticides. The temperature and humidity during and after treatment may affect the behaviour and activity of the insects and hence the dosage of insecticide picked up, the rate of penetration and action of the insecticide, and the speed and extent to which it is excreted or metabolished. Furthermore, environmental conditions may affect the physical state of the insecticide and its availability to insects.

This paper is concerned with the effects of temperature and humidity during the post-treatment period on the toxicity of four insecticides to adult mosquitoes and houseflies.

Individual mosquitoes (*Aedes aegypti*) and houseflies (*Musca domestica*) were treated with small volumes of kerosene solution of DDT, gamma-BHC, dieldrin or Diazinon, and batches of mosquitoes were exposed for a short contact period to deposits from aqueous suspensions of DDT, gamma-BHC or dieldrin wettable powders. After treatment, the insects were stored at different temperatures and different humidities.

The toxicity of DDT to mosquitoes and houseflies decreased substantially as the post-treatment temperature increased from 20 to 30°C, whereas the toxicity of dieldrin and Diazinon to mosquitoes and houseflies increased as the post-treatment temperature increased. Temperature had little or no effect on the toxicity of gamma-BHC. Differences in atmospheric humidity after treatment had no significant effect on the toxicity of any of the insecticides.

57/38 THE INFLUENCE OF TEMPERATURE AND HUMIDITY UPON THE ACTION OF INSECTICIDES. PART II: TEMPERATURE DURING THE PRE-TREATMENT PERIOD.

A.B. HADAWAY and F. BARLOW. Colonial Pesticides Research Unit, Porton. Report No. 131. February 1957.

An account is given of the effect on susceptibility of rearing and maintaining test insects (*Aedes aegypti* L.; *Musca domestica* L.) at two temperatures (25°C or 30°C) before topically applying kerosene solutions of DDT, dieldrin or γ BHC.

It is pointed out by the authors that merely to investigate the effect of different temperatures at one age only is not enough, since temperature affects the rate of development and feeding habits of insects, and mosquito insecticide susceptibility is influenced by nutritional status. LD$_{50}$s have therefore been determined at different stages in the feeding cycle and the effect of age of the adult insect on susceptibility noted.

It has been shown that at the higher temperature eggs of the housefly are laid a day earlier and mosquito feeding cycles are of shorter duration. At both temperatures LD$_{50}$s for female mosquitoes varied in a regular manner through successive feeding cycles; LD$_{50}$s for female houseflies increased with age to a maximum when eggs were produced in large numbers. Male flies were found to be more susceptible than females to insecticides.

It may be concluded that after allowing for post treatment effect, pre-treatment temperature does not significantly affect the susceptibility of these insects in similar physiological states.

57/39 THE SUSCEPTIBILITY OF AEDES AEGYPTI LARVAE OF DIFFERENT AGES TO DDT AND DIELDRIN, AND THE RELEVANCE OF THE RESULTS TO THE FORMULATION OF STANDARDISED SUSCEPTIBILITY TESTS FOR MOSQUITO LARVAE.

A.H. PARKER. Colonial Pesticides Research Unit, Porton. 1957.

Aedes aegypti larvae were reared and tested under carefully standardised conditions. At 25°C, eight days were normally spent in the larval period. The larvae were separated into eight age-groups, each one day older than the other.

Recrystallised pp' DDT or dieldrin was dissolved in acetone to form stock solutions of 0.1%, 0.01% and 0.001%. Series of solutions for each experiment were made by progressive dilutions from the stronger solutions.

Twenty larvae were transferred from the breeding medium to distilled water to which was added insecticide solution to make the correct concentration. After exposure periods of one or twenty-four hours, the larvae were transferred to tap water and then to the breeding medium. The number of larvae mortally affected was assessed by counting those which failed to migrate to the dark end of a trough illuminated at one end by a 60 watt bulb.

When mortality was assessed immediately after a one-hour exposure, DDT appeared to be much more toxic than dieldrin to fourth instar larvae, but after a further 24 hours in the normal rearing medium the reverse was true. Thereafter mortality changed little up to the time of pupation. A 24-hour 'recovery' period was therefore allowed when exposures were for one hour.

When exposures were for 24 hours, mortality as assessed immediately after exposure differed only slightly from the readings obtained after a further 24-hour recovery period, and still later readings up to the time of pupation showed little further change. Thus a recovery period did not appear to be very important with exposures of this length.

With one-hour exposures the age-group displaying the highest susceptibility to DDT and dieldrin was the second day (first instar). From then onwards there was a significant rise in median lethal concentration (LC50) on each successive day of development. The LC50 of first day larvae was higher than that of both the second day (first instar) and third day (second instar).

Only fourth to eighth day larvae were tested in the 24-hour exposures, earlier age-groups being subject to a high mortality in the controls. The LC50 of both DDT and dieldrin rose on each successive day.

Whatever the insecticide or the exposure period, the variation within the fourth instar was invariably greater than that within the third.

When exposures were for one hour the LC50 of dieldrin was significantly higher than that of DDT up to the fifth day (third instar), but from the sixth day (fourth instar) onwards the reverse was true. When exposures were for 24 hours the LC50 of dieldrin was the higher up to the sixth day; thereafter there was no significant difference. This may have been due to differences in the physical state of the insecticide.

For standardised susceptibility tests, it was considered that third instar larvae appear to be preferable if 24-hour exposures are carried out with solutions made up with distilled water.

57/40 A PRELIMINARY REPORT ON THE RESIDUAL PROPERTIES OF DDT AND DIELDRIN ON SOME MATERIALS USED FOR HOUSE CONSTRUCTION.

F. BARLOW and A.B. HADAWAY. Colonial Pesticides Research Unit, Porton. Report No. 139. April 1957.

Bamboo, palm leaf thatch and a plywood, constructed in the form of 3" x 3" test panels, were sprayed with pp' DDT or recrystallized dieldrin, each of particle size 0-10 microns, at 50 mg/sq.ft. Glass plates, similarly sprayed, were employed as standard test surfaces. Treated panels were stored horizontally in a cupboard (room temperature 25°C; Relative Humidity 60-70%). Deposits were sampled immediately after spraying and at three and six monthly intervals.

Techniques devised for removing the deposits before analysis are described. Adequate recoveries were obtained from glass and palm leaf surfaces using cotton wool swabs with and without acetone respectively. Adhesive tape was found effective on bamboo. On the plywood panels however, it was found that part of the insecticide had penetrated into the first layer of wood (1/50" deep). Recovery in this case was affected by removing shavings from the top layer for extraction following external treatment of the surface with adhesive tape.

Analysis of DDT was by a simplification of the Schechter-Haller method; dieldrin was estimated by reduction with sodium and isopropanol followed by potentiometric titration.

It is apparent from the results (see overleaf) that, at the dosages used, DDT remains constant whilst dieldrin steadily evaporates. The conclusion is drawn that insecticides such as DDT and dieldrin can, on the materials tested, be expected to behave as they do on inert surfaces such as glass or metal. There is no suggestion of any chemical decomposition or of the dramatic changes in physical state which have been observed on many of the soils used for making walls. It is noted that the percentage of insecticide lost by simple penetration on spraying the wood is not likely to be sufficient to cause a reduction in biological activity although the amount will presumably vary from one kind of wood to another depending upon the closeness of the grain.

Dosages of DDT and dieldrin in mg. per sq. ft. on various surfaces

Surface	Time after spraying in months					
	0		3		6	
	DDT	dieldrin	DDT	dieldrin	DDT	dieldrin
Glass	49	54	-	-	49	19
Bamboo	47	49	-	-	47	25
Palm Leaf	47	45	-	-	42	16
Wood, surface deposit	31	27	34	17	32	13
" , first layer	16	18	18	10	19	9
" , second layer	0	0	0	0	1	0

57/41 THE SORPTIVE PROPERTIES OF SOILS FROM DISTRICTS WHERE CONTROL OF MOSQUITOES IS BEING ATTEMPTED BY HOUSE SPRAYING.
I, SAMPLES FROM IRAN.

F. BARLOW and A.B. HADAWAY. Colonial Pesticides Research Unit, Porton. Report No. 140. April 1957.

Assessment of sorption capacity is recorded for three samples of soils taken from house walls in Southern Iran localities, where resistance of A.saccharovi had been encountered.

Test procedure is described. Soils were ground, sieved through a 30 I.M.M. sieve and made into small blocks. Some blocks were sprayed with 0-10 micron suspension of pp' DDT or of recrystallised dieldrin at 100 mg/sq.ft., then stored at 25°C (Relative Humidity 60-70%). Losses of deposit were assessed from time to time by comparison with unsprayed blocks of the same soils. Blocks of a standard Uganda lateritic soil were also sprayed.

Results are reproduced below. Iran samples are shown to be of low activity but sufficient, it is suggested, for dieldrin and possibly DDT to be in the sorbed state during most of the probable time interval between sprayings, excluding very high relative humidity.

Sorption of carbon tetrachloride by the Iran soils was 11, 7 and 6 per cent respectively which gives the same order of activity as the times for DDT sorption but not for dieldrin. However, it is known that correlation between the two tests is not good with less active soils.

This is the first report on a series of tests which have been planned in conjunction with the World Health Organisation to investigate the sorption effect on various soil samples under field conditions.

Results

Soil	Origin	DDT	Dieldrin
Standard	Uganda	2-3	1-2
Sample 1	Dadin Bola, Iran	14-21	7-11
" 2	Sasan, "	21-28	6-7
" 3	Polabginh, "	35-42	11-14

Figures denote time in days for substantially complete loss of insecticide from the surfaces.

57/42 "BUNCHY TOP" DISEASE OF ABACA. (THE MANILA HEMP) (MUSCA TEXTILIS NEE) IN NORTH BORNEO.

T.H. WILLIAMS. Summary of Progress Report January 1955 to March 1956.

During the period January to August 1955, there was a high incidence of disease in areas of the estate planted in 1952 and 1953, and a relatively low incidence in those planted in 1950-51 and 1954.

Symptoms of the Disease

External symptoms of the disease observed since January 1955:-

1. Leaves are very short and the lamina is reduced.
2. Chlorosis of leaves - diffuse or in bands, which turn pale green, then yellow, and then possible orange or transparent.
3. Discontinuous, dark brown streaks appear along the main and subsidiary veins, usually associated with chlorosis.
4. Discontinuous purple or continuous black streaks on the midrib or petiole.
5. Translucency of the main and subsidiary veins of the lamina may occur.

Internal symptoms observed are:-

1. A dark brown gummy substance within the vascular strands which causes the appearance of the dark streaks on the veins, midrib, and petiole (above). The substance is always present in the sieve tubes and often in parenchymatous cells adjacent to the phloem; it is rarely seen in the xylem.
2. Anatomical changes usually accompany the 'gumming'. Phloem may be partially replaced by hypertrophic cells or less commonly by hyperplastic cells. Sclerenchymatous cells of the abaxial sheath may be partially replaced by large hyaline, hypertrophic cells.
3. When veins become translucent, the abaxial chlorophyllous tissue has been replaced by hyaline hypertrophic tissue, and changes may occur in the abaxial bundle sheath.

Symptoms resembling those of 'Bunchy Top' can however result from insect damage or sun scorch. Symptoms of the disease are being studied in an Experimental Plot which is planted with whole corms, quarter corms, and single buds taken from hemp plants which show early, intermediate or advanced stages of the disease; also in banana corms from infected plants. The resultant plants were sprayed twice weekly with 0.5% Agrocide solution against aphids, and the progress of the disease is recorded for each plant. Most hemp plants have shown either mild symptoms or none at all, even though many plants are more than six months old; no symptoms were observed on plants from quarter corms or single buds. Some plants which previously showed symptoms were free of symptoms up to March, 1956. Banana plants have shown more severe symptoms than hemp plants, and once a plant expressed symptoms it continued to do so.

Aphid Studies

The aphid vector Pentalonia nigronervosa was normally found in association with ants, in particular a small, black ant and a larger brown ant. Aphid populations were larger during cool, wet weather than in dry, hot weather. In the mature abaca mats, the greatest concentration of aphids accurs on the young suckers, but on very young mats there was no obvious difference in distribution of aphids on plants of different sizes. Aphids were normally found in relatively inaccessible parts of the plant such as inside the 'funnels' of partly unfurled leaves.

Spread of the Disease

A number of blocks of plants have been mapped for the incidence of disease on individual plants. Infected plants are eradicated. The initial incidence of disease within an area follows a sporadic pattern, indicative of the activity of winged vectors. Most of the subsequent spread is then to plants adjacent to, or two parts away from an already diseased plant. This is associated with activity of wingless vectors. The effects of this contact spread is masked in heavily diseased areas.

Insecticide Experiments (January-September 1955)

Preliminary experiments were conducted in the laboratory with various contact insecticides and the systemic insecticide, Metasystox.

The effects were studied of solutions of Agrocide (0.5%), nicotine sulphate (0.05%), dieldrin (0.05%), and endrin (0.25%), with and without the addition of the wetting agent, Lissapol, on P.nigronervosa and on the attendant brown ant. Ten aphids per petri dish were sprayed for 15 secs. with 'Flit guns' for each solution tested. Two or three tests for each insecticide were made in most experiments. The numbers of dead insects were counted at minute intervals.

Results were variable, but all solutions with addition of Lissapol (1:1200 parts) were capable of killing aphids within 5 to 10 minutes, and brown ants within 5 minutes. It was concluded that Lissapol increased the effectiveness of the insecticides, especially with nicotine sulphate, but least with dieldrin. Lissapol (1:1200) in water had a completely lethal effect on aphids within 13 minutes.

Insecticide Experiments (October 1955 - March 1956)

Contact insecticides were tested in the laboratory with addition of varying quantities of lissapol against P.nigronervosa.

Solutions tested:- Agrocide 0.5% Dieldrin 0.05%
Nicotine sulphate 0.05% Endrin 0.25%
and 0.05%
Lissapol concentrations:- 1:1200, 1:1600, 1:2000 parts solution.

Ten aphids per petri dish were sprayed for 15 secs. for each solution tested (repeated 10 times), and aphid kills were observed at minute intervals.

Increasing the level of Lissapol increased the efficiency of each of the insecticides. The water plus Lissapol controls gave better results than the Agrocide, dieldrin and endrin when used with a corresponding concentration of Lissapol.

When both the early kills and the times necessary for a complete or almost complete aphid-kill are considered, the best results were obtained with nicotine sulphate, followed by dieldrin, endrin (0.05%), Agrocide, and endrin (0.025%).

The persistence of the insecticides plus Lissapol (1:1200) sprayed on young potted plants was studied by confining aphids on young leaves for 24 hour periods, immediately the solution had dried, one day and two days after spraying. Dieldrin (0.05%) had no effect. Agrocide (0.5%) and endrin (0.05%) gave mortalities of 67.5% and 77.5% during the first period, when control kills were 7.7% for water and Lissapol, and 10.3% for untreated plants. Agrocide gave a kill of 48.7%, 2 days after spraying when effects of other insecticides had apparently been lost.

Field Experiments with Systemic Insecticides

In preliminary experiments on one year old plants, 0.1%, 0.5% and 1.0% solutions of systemic insecticides were tested, with the following treatments:-

Metasystox - soil and foliar applications
Systox - foliar applications
Pestox 3 - soil and foliar applications
Hanane - soil applications

Soil applications were made at the rates of 2 gallons and 4 gallons per mat, with the exception of hanane which was at 4 gal/mat only. Aphids were confined on young leaves of one plant per mat at varying intervals up to four weeks after the application for feeding periods af 24 hours.

Poor results were obtained with both foliar and soil applications of Pestox 3, and the effective treatments of hanane were also phytotoxic and its use for further tests was discontinued.

There was no obvious difference between the effectiveness of foliar applications of systox and metasystox. Soil applications of metasystox were similar but with slightly better persistent effect.

With metasystox the results were variable, but during the first three days following soil application, the 4 gal. rate of 1% solution gave between 83% and 90% kill. The 2 gal. rate of 1% solution gave 96.8% kill after the first day and 63% on the third day. The 4 gal. rate of 0.5% solution gave 85.7% kill. After the first three days the results became progressively poorer until after three weeks all treatments had only slight effect.

Foliar applications of metasystox 1% and 0.5% solutions gave between 93% and 86% kill during the first three days, but after one week the effect of both had fallen considerably.

The 1% systox solution gave 100% kill after the first and second days and 60% after one week. Fairly good results were obtained with 0.5% solution.

A further experiment was conducted with soil treatments of metasystox at the high concentrations of 1%, 2% and 3% solutions, at 2 gal. and 4 gal. solution per mat. Aphids were confined for periods of 24 hours and 48 hours at varying periods up to four weeks after the treatments.

Consistently better aphid kills were obtained with the 48 hour feeds, and 4 gal. applications gave better results than 2 gal. application for each solution. The 3% solutions at 2 and 4 gals. gave kills ranging from 100% down to 77% after five weeks. The 4 gal. rate of 1% solution gave kills between 70% and 90% for two weeks after application. Other applications gave less satisfactory results.

57/43 THE MICROCLIMATE OF IRRIGATED COTTON. (Author's Summary).

R.T. JARMAN. Ministry of Agriculture, Entomological Section, Wad Medani, Sudan.

This report describes the initial results, and the work in progress, to measure the microclimate in irrigated cotton and to relate this to the macroclimate, the vegetation density, and the irrigation practices. It was found that the air in the cotton crop is cooler and damper than that at the meteorological screen level, and the effect increases with crop density. Considering the heat and water vapour exchange process it is inferred that the transpiration of the leaves is an important casual factor. Comparison with records obtained in a potato crop in England, show marked difference and it is inferred that a small number of careful simple measurements on the actual site, are more reliable than theorising using only results obtained at other places and with other crops.

57/44 THE RELATION BETWEEN INFESTATION BY MAIZE STALK BORER AND YIELD OF MAIZE

P.T. WALKER. Colonial Pesticides Research Unit, Arusha.
Misc. Rep. No. 179. March 1957.

Arising out of experiments to control maize stalk borer (mainly *Busseola fusca*) insecticide treatment has provided a range of associated yields and infestations.

Observations have been expressed by the writer as a series of regression lines for crops of different potential yields, Reasons are given for assuming linear regression, denoting that crop damage develops in a proportional, straightforward manner, and that change in regression, or rate of fall in yield, is proportional to the maximum expected yield of the crop. The regression coefficients for high and low cropping maize are given as -.4 and about -.2 respectively.

The validity of "yield factor", control economics and accuracy of sampling methods are discussed. The subject of infestation and crop losses is briefly reviewed.

57/45 AIRCRAFT APPLICATIONS OF INSECTICIDES IN EAST AFRICA. XII - AN EVALUATION OF THE EXPERIMENTS AGAINST TSETSE FLIES. AND A DISCUSSION OF THE PERMANENCE OF THE REDUCTIONS IN POPULATION.

K.S. HOCKING, D. YEO, G.F. BURNETT. Colonial Pesticides Research Unit, Arusha, Tanganyika.

The technique of applying insecticide to the best advantage against East African tsetse is reported in the light of investigations conducted over several years.

The general approach has been based on results obtained in preliminary experiments. Indications are that aircraft sprays to be effective must be applied to relatively open "savannah" woodland; that space sprays are superior to residual deposits at similar nominal dosages; that normally, a standard spray procedure, consisting of eight applications at fourteen day intervals, is required. Oil solutions of technical BHC and DDT were adopted for spraying, at rates equivalent to 0.20 lbs/acre p,p' DDT and 0.03 lbs/acre γ BHC.

The final level of success has not been consistent and results are scrutinised with regard to the factors involved, including the relationship between the life cycle of tsetse and frequency of spray treatment. Species of tsetse, initial population densities and spray droplet sizes are recognised as significant factors in control. Other factors, qualifying the use of aircraft, are terrain (which should, preferably, be flat or slowly undulating), type of vegetation (dense evergreen and generally high forest is not suitable), and the season (heavy rains should be avoided). The swathe width and overlap also are significant. It is strongly emphasised that lasting control can only be secured if the treated area is isolated from other infested woodland.

The deviation between theoretical predictions and actual results is considered with particular reference to the number and periodicity of applications. A revision of certain basic assumptions is proposed. Population dynamics of treated areas are studied and it is concluded that in the absence of invasion there is no detectable tendency for a population to return to its pre-treatment level.

It is concluded that the applicability of this method is at present restricted by its high cost and low effectiveness; and that improvement may be affected by using more concentrated solutions of more toxic insecticides (e.g. dieldrin or lindane) applied as space sprays with droplet distributions of mass median diameter 20-30 microms, from single-engined aircraft carrying payloads of 60-80 I.G.

57/46 COUNTS OF PSEUDOTHERAPTUS WAYI, A SERIOUS PEST OF COCONUT PALMS IN EAST AFRICA.

D. YEO and R. FOSTER. Colonial Pesticides Research Unit, Arusha.

A critical approach is made to the method of counting adults and nymphs of the Coreid bug, Pseudotheraptus wayi, for rapidly assessing the effectiveness of insecticidal treatment of infested palms.

It is indicated that reliable counts may be obtained with samples of 100 palms which number should be increased where insecticide has been applied or when interest is centred upon the older instars. A spadix is proposed as the unit of search, the crowns being systematically inspected by progressing from spadix to spadix. Analysis of the numbers caught suggest that nymphs are concentrated in certain palms, (non random distribution).

Palms infested with Oecophylla longinoda - important ant predator of Pseudotheraptus - or stunted and immature palms, were not included.

57/47 QUELEA IN KENYA

Department of Agriculture Report 15.9.56 - 31.12.56.
Received from the Joint Secretariat C.C.T.A./C.S.A.
African Headquarters, Bukavu.

Quelea quelea aethiopica cause widespread damage among grain crops (sorghum, millet and rice) in Kenya. Breeding occurs extensively in Ethiopia and in various local areas of the territory. Acacia trees are suspected as having provided roosts near Moyale. The general pattern of annual migration is not yet complete but it appears that birds which move northwards from the main breeding areas in Central Tanganyika during May/June reach S.Kenya in September/October. Breeding is attempted under favourable conditions. Birds normally return to Central Tanganyika during February for the next season. Large migrations have been observed along coastal areas.

Control measures are reported. No attempt has been made to spray parathion because of the proximity of the roosts to water supplies or populated areas. Instead explosive charges (Dynagel and fuel) are used. Positioning of the charges can be hazardous since most of the roosts are situated in tall reeds which grow in swamps or large dams. Seventeen 'blow-ups' are stated to have resulted in the destruction of well over 4 million birds.

Notes of biological interest are given and reference is made to future projects. Results of examination of male and female birds and results of control measures are listed.

57/48 BIRD DAMAGE AND CROP PROTECTION IN WEST AFRICA

J.H. CROOK. Department of Zoology, University of Cambridge.

The various birds causing damage are described in relation to the territories visited. Species of the weaver bird family including Quelea spp. and Plesiositagra cucullatus (village weaver) are present throughout the West African territories of Ghana, Nigeria, Sierra Leone, Gambia and Senegal.

Quelea cause severe damage every year to rice cultures in Senegal and constitute a serious potential threat to development schemes in other territories, such as Quelea q quelea in the thorn bush savannah of Northern Nigeria.

The village weaver, which roosts in trees near village settlements, causes considerable damage to grain crops including corn, millet and rice. When nest building the birds will strip coconut and oil palms of their leaves.

"Bishop" birds (Euplectes spp.) are identified as significant grain pests in Ghana, Nigeria and Sierra Leone. Euplectes, which breeds in grassland areas, is most detrimental during the dry season.

The Chestnut and black weaver (Cinnamopteryx castaneofuscus) found in association with the village weaver in Nigeria, also attacks grain and palms. Other weavers present in Nigeria include Sitagra capitalis, which form loose colonies along the river Niger and attack the rice, and Quelea erythrops. Sitraga melanocephala (or capitalis) is suspected of damaging rice in Gambia. Crows are stated to attack corn cobs and seedling maize in Ghana.

Local methods of protecting crops from bird damage are indicated. Traditional methods dependant upon noise and movement produced by percussion instruments either in the hands of children or suspended from ropes stretching over the fields, are still widely employed. These appear to be preferred to more modern methods which include sirens, detonators and smoke screens. A short account is given of the habituation of birds to stimuli.

The *Quelea* problem in West Africa, discussed in another section, is attributed to the extreme sociability of the species and the immense size of the areas used in rice schemes for cultivation.

A traditional plan of campaign against *Quelea* in the Senegal valley is described and a method is proposed for protecting palms from village weavers.

In a final section headed "Destruction, Control and the Balance of Nature", the writer warns that "In our present state of ignorance concerning the natural balance between bird and insect populations in Africa, indiscriminate slaughter of birds is to be deprecated."

57/49 EXTRACTS FROM KENYA DEPARTMENT OF VETERINARY SERVICES ANNUAL REPORT 1955.

Insecticides as Systemic Poisons in Cattle

In earlier experiments, Pollard and Langridge of this Department found that aldrin (technical 83 per cent) given orally at 0.02 gm/kg was tolerated by cattle and an active insecticidal ingredient was absorbed into the bloodstream in a concentration sufficient to kill tsetse flies which fed on the treated animals for at least 7 days after a single dose. Later experiments showed that after a series of four doses given at intervals of approximately one week, tsetse flies were all killed up to 30 days after the final dose while a 70 per cent kill was maintained up to the 60th day, but after that the insecticidal effect fell off rapidly. From these results a field experiment was planned and treated cattle were exposed in the tsetse bush of a known fly density. Unfortunately loss of the bait cattle from East Coast fever, and also deaths due to aldrin poisoning necessitated closing the experiment down until the cause of increased toxicity of the aldrin had been discovered, for tests showed that while the toxicity to cattle had increased the insecticidal value had decreased in the new supply of aldrin which was used and at the dosage of 0.02 gm/kg it seriously affected some animals and killed one. Treatment with atropine, when systems of shock were first noticed, resulted in rapid recovery in nearly every case. A fresh supply of aldrin was obtained from another source and further tests carried out. The results to date are shown below:

Percentage Kill of Tsetse Flies (G.austeni) on Cattle Dosed with Aldrin

No. of doses	Dosage rate gm/kg	Experiment No.	No. of days after final dose of aldrin				
			0-10	20	40	50	60
2	0.02	A	100	70	20	ø	ø
2	0.02	B	90	40	10	ø	ø
2	0.02	C	50	60	20	ø	ø
2	0.02	D	20	20	20	ø	ø
3	0.02	A	90	40	ø	ø	ø
3	0.02	B	20	20	ø	ø	ø
4	0.02	A	100	100	40	25	ø
4	0.02	B	80	60	100	60	20
4	0.02	C	50	70	80	20	ø
4	0.02	D	100	60	25	20	ø
4	0.02	E	80	90	50	20	ø

ø No test made.

In view of the rather erratic results obtained with aldrin, it was decided to again try dieldrin as a systemic poison, and a series of tests are now being carried out. Malathion was also tried and though it was well tolerated by cattle in our tests it did not appear to be as effective as aldrin or dieldrin.

It is perhaps of interest to record that aldrin, as a systemic poison, did not protect the cattle from tick infestations and several animals succumbed to East Coast fever, when experiments in the field were being carried out.

Insecticide Spraying Tests

The Kiekens-Dekker mistblower (shoulder-mounted type) and the pneumatic knapsack sprayer (Four Oaks) were compared experimentally. The mistblower proved much superior because its powerful jet of air produced a more even deposit of insecticide and gave greater penetration into the vegetation. It was also more economical and used about one-third of the amount of spray mixture required to cover a similar area with the Four Oaks type, but it has the disadvantage that some mechanical knowledge is required to keep the machine in good running order.

In addition to this a Swingfog machine was tested in the Sokoke Forest under early morning and afternoon conditions. It was found that in the morning the fog generated by the machine was quickly drawn up into the upper and middle strata of the vegetation by air currents while that which remained in the undergrowth was visible for 25 ft. only. In the afternoon, however, high winds forced the fog down into the undergrowth, where gaps in the upper canopy occurred. Tsetse flies were exposed at varying distances from the machine at ground level and 4 ft. up. In the afternoon there was 100 per cent kill up to 50 ft. from the machine, but in the morning fogging was not effective beyond 25 ft.

Testing New Insecticides

Previous experiments had shown that insecticides in solution in kerosene and/or diesoline oil were unsatisfactory as they caused defoliation of the vegetation so that water-miscible formulations seemed to be more suitable. This line was pursued further.

Two commercial emulsion concentrates "Arkotine S.D.18" [*] and "Dieldrex 15"[*], produced by Messrs. Shell Chemicals Ltd., were tested for toxicity and persistence under field conditions, when applied with the Kiekens-Dekker mistblower at the rate of approximately 1 gallon to 250 yards of bush to a height of 9 ft. along a pathway. Application at this rate thoroughly wetted the vegetation to the point where the spray began to drip or run off.

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[*] Arkotine S.D.18 — 18% DDT with an activator in hydrocarbon solvent.

[*] Dieldrex 15 — 15% dieldrin in hydrocarbon solvent with emulsifying agent.

Arkotine S.D.18 (diluted with water to yield a 5% DDT emulsion, left a shiny coating to the vegetation immediately after application, and did not smell strongly. Acicular crystals of insecticide were formed within 24 hours, but were not closely bunched. After three weeks the crystals were much less apparent and had been replaced by a flat grey, scale-like surface on the leaves. After 55 days little insecticide was visible, and 15 seconds' contact exposure of tsetse flies indicated that its killing power was decreasing. On the 90th day only 10 per cent of the flies exposed died within 24 hours. The results, showing a typical example of test exposures, are tabulated below:

Exposure of Tsetse Flies to Vegetation Sprayed with Arkotine S.D.18 Emulsion. (5% DDT)

Species of Tsetse G. austeni	No. of days after exposure of flies	Per cent mortality of flies				
		Days after spraying				
		7	21	35	56	90
15 second exposure	1	80	60	80	40	10
	2	100	60	80	70	-
	3	-	80	90	-	-

In addition to this, glass plates were exposed approximately 6 ft. from the sprayer, and on each droplets of spray were deposited almost wetting the whole surface. Examination with a dissecting microscope showed that acicular crystals of DDT formed a spiderweb-like cover over the plates which was still visible 90 days after being kept in a room.

In order to reduce the tendency of this spray to form long slender crystals, the addition of resins was tried. Coumarone resin at 1 per cent W/V of spray (i.e. 20 per cent resin to arkotine insecticide) was added to the concentrated solvent before making the emulsion. The spray formed a shiny, gluey surface when dry. No crystals were visible for 48 hours but on the fifth day the whole surface was covered with fine crystals giving a frosted appearance under magnification. Some leaf burn was noticeable on younger leaves and much defoliation occurred after two months. With the coumarone resin content reduced to 0.5 per cent W/V crystals began forming in the gluey substance in 24 hours and on the fifth day bunches of fine acicular crystals had been formed on the surface. Some burning and defoliation occurred within 40 days but was not as severe as the former test. On the 72nd and 90th days after spraying, the remainder of the crystals has formed into greyish white lumps and the greater proportion of the insecticide had disappeared.

A local gum copal resin obtained from *Trachylobium verrucosum* which grows at the coast was tried instead of the coumarone resin. It was prepared by heating the gum until it melted. At o.5 per cent W/V of arkotine spray, this resin had little effect in reducing the size of the crystals.

Type of spray	Tsetse species	No. of days after exposure	Per cent mortality of flies			
			Days after spraying			
			28	56	72	90
Arkotine + 20 per cent coumarone resin	*G. austeni*	1	100	100	60	50
	15 seconds	2	-	-	100	90
	exposure	3	-	-	-	-
Arkotine + 10 per cent coumarone resin	*G. austeni*	1	100	100	100	100
	15 seconds	2	-	-	-	-
	exposure	3	-	-	-	-
Arkotine + 10 per cent copal resin	*G. austeni*	1	60	50	40	60
	15 seconds	2	70	-	60	70
	exposure	3	-	-	80	-

Dieldrex 15 (diluted to 5 per cent dieldrin in the total volume of emulsion). Dieldrex leaves a chalky white deposit as it dries out and crystals form in 24 hours. These crystals tend to group and are rather longer and thicker than those of DDT. The spray has a strong petroleum smell which persists for several days. Little effect on vegetation is noticeable at first but later pale zones followed by craters form on sprayed leaves. The deposit is not strongly adhesive and the crystals tend to wash away or fall off during heavy rains. It has a much better adhesive tendency on rough surfaces such as the bark of trees. (See table below).

Type of spray	Species of Tsetse	No. of days after exposure	Per cent mortality of tsetse flies Days after spraying				
			7	21	35	56	90
Dieldrex 15	G.austeni	1	100	100	90	40	10
(5 per cent)	15 seconds	2	-	-	100	80	30
emulsion)		3	-	-	-	90	-

The tendency for the large crystals of insecticide to become dislodged from leaf surfaces presented the same problem as that met with in Arkotine but the addition of resin did not improve the results as it was found that unless the amount of resin used in proportion to insecticide was increased to a point where the crystals were retained in the gluey base, large crystals still tended to form. When 10 per cent resin was added small white dots formed on the surface of the gluey base, but this mixture damaged the leaves and pale areas soon formed which gave place to dead patches, then craters, and eventually the leaves were dropped, However, the white dot deposit disappeared fairly quickly, and on testing spray containing the additional resin it was found to be as effective as that without it. (See table below).

Type of spray Dieldrex 15 5 per cent emulsion copal resin	Species of tsetse	No. of days after exposure	Per cent mortality of tsetse flies			
			Days after spraying			
			28	56	72	90
Dieldrex 15, 10 per cent copal resin	*G.austeni*	1	60	50	40	60
		2	70	-	60	60
		3	-	-	80	70

Other Spray Mixtures:- Further experimental sprays were tried using technical DDT or dieldrin but to obtain finer crystal sizes xylol was used as the solvent. Resins were added to improve the emulsification but separation of the emulsion was rapid. However, this was overcome by the addition of a small amount of skimmed milk. Later, casein in place of skimmed milk was used with good results. Local pipeline water which is slightly brackish also accelerated separation of the emulsion.

DDT, Xylol, Dieldrin and Resin Mixture - Both copal and coumarone resins were tried with DDT or dieldrin in a xylol solvent. Both mixtures produced crystals much finer than those obtained with dieldrex 15 or arkotine S.D.18 and sprayed vegetation was covered with fine sparkling crystals formed on a gluey base. After 21 days the crystals had a greyish-white appearance. On the 78th day a few of the sparkling crystals remained in a greyish-white powder which had formed on the gluey base. It was found that coumarone resin slightly delayed the change to the greyish-white stage.

Type of spray	Species	No. of days after exposure	Per cent mortality of tsetse flies				
			days after spraying				
			7	21	35	90	108
K.24 DDT	G.austeni	1	80	100	100	100	100
Xylol		2	100	-	-	-	-
Copal resin		3	-	-	-	-	-
J.23 dieldrin	G.austeni	1	100	100	100	90	40
Xylol		2	-	-	-	90	70
Coumarone resin		3	-	-	-	100	100
K.25 dieldrin	G.austeni	1	ø	100	100	80	ø
Xylol		2	ø	-	-	80	ø
Copal resin		3	ø	-	-	80	ø

ø not tested.

Tests showed that the effectiveness of spraying vegetation as a method of tsetse control is limited by many conditions, the most important of which are type and growth form of the vegetation and exposure of the sprayed material to rain and high temperatures. Most of the tests described above were done in the "coral rag" thicket at Kilifi where the vegetation is mainly evergreen and fairly dense while growth and the production of new leaves following heavy rain reduces the possible fly-insecticide contact considerably. Where the vegetation was exposed to direct rainfall much of the insecticide was washed off and the change from bright, sharp crystals to dull, grey-white flakes or powder which soon disappeared, indicated that the insecticide is destroyed by exposure. Areas exposed to direct sunlight were rapidly affected.

Examination of sprayed vegetation at weekly intervals showed that in hot weather with very occasional rain, spraying should be done at intervals of not less than 30 days but in rainy periods it would be necessary to spray more frequently.

The object of the above experiments using different types and concentrations of resins and insecticides was to endeavour to discover a means of producing small crystals in a durable base which would give greater resistance to heat and rainfall. Of the solvents used xylol produced the most promising results.

57/50 OLFACTORY STIMULATION OF TSETSE FLIES AND BLOWFLIES

J.C. HUGHES . Imperial College Field Station, Silwood Park.
May, 1956.

Olfactory stimulation in adult Glossina palpalis R-D and G.morsitans West., together with (in some cases) Protophormia terraenovae R-D was studied, using known concentrations of vapours of a number of organic compounds. The responses to different concentrations of various vapours have been correlated with variations in the physical preparations of the compounds as a guide to the properties of good olfactory stimulants.

For the main experiments, the use of "choice chambers" is abandoned and an alternative apparatus, which measured the activation of flies by known concentrations of vapours without reference to the attractiveness or repellency of the vapour, was substituted.

Air was passed through towers containing calcium chloride and activated charcoal to remove water vapour and organic impurities. The dry deodorised air was divided into three streams, the rate of flow of each being regulated by a needle valve and measured on a flowmeter. The first stream was passed straight to a mixing bottle. The second and third air streams were passed through saturators containing the liquids to be tested, and then to the mixing bottle. The air then containing a vapour of known concentration was passed into a five-litre bolt-head flask containing the test insects, and thence passed out of the building.

Under stimulus the flies first made cleaning and probing movements until they were excited to fly, and measure of activity could be obtained by counting the number of seconds of consequent flight. Observations were made through a hole in a screen surrounding the test flask.

A standard procedure was adopted on the results of preliminary experiments with vapours of four carboxylic acids present in decaying animal sweat. Five flies of one sex, fed and isolated the previous day, were selected by random number tables for each test. Samples of male and female flies were used alternately. A count was taken of the number of seconds each fly was in flight during each minute of five minutes while in dry odourless air and in the vapour under test. Also the time was recorded at which each fly left the surface when in the vapour. Rate of flow of air stream was 100 ml/sec, temperature 26°C, and light intensity 25 ft. candles.

The compounds tested fell into four groups:

1. Compounds present in decaying animal sweat and excreta, including the homologous series of liquid monocarboxylic acids from formic to pelargonic acid, and a few amines.

2. Compounds known to be repellent to other blood sucking Diptera, including a selection of liquid aliphatic straight chain mono-alcohols, ethyl esters and acetates.

3. For comparison with the homologous series of acids, alcohols and esters; the third group consisted of hydrocarbons and compounds with more than one functional group, which included hydroxy and unsaturated acids and esters, chlorinated esters, and glycols.

4. Vapours from sump oil and exhaust gases of cars were tested on *G.palpalis*. It was shown that compounds that stimulated tsetse flies at very low concentrations were not likely to be present in large quantities in the products of combustion of cars.

Compounds in groups 1, 2, 3 were mostly obtained commercially, and are listed below. They were tested against *G.morsitans* and *Protophormia terraenovae*.

Formic acid
Acetic acid
Propionic acid
Butyric acid
Valeric acid
Caproic acid
Heptylic acid
Caprylic acid
Pelargonic acid
Acrylic acid
Lactic acid

Ethanol
Iso-propanol
n-propanol
iso-butanol
n-butanol

n-pentanol
n-hexanol
sec-hexanol
tert-hexanol
cyclohexanol
n-heptanol
n-octanol
n-decanol
Benzyl alcohol
Ethylene glycol

Ethyl acetate
Ethyl butyrate
Ethyl valerate
Ethyl caproate
Ethyl caprylate
Ethyl caprate

Ethyl laurate
Ethyl myristate

Butyl acetate
Amyl acetate
Hexyl acetate
Cyclohexyl acetate
Octyl acetate
Decyl acetate
Lauryl acetate
Cetyl acetate

Ethyl crotonate
Ethyl lactate

Ethyl monochloroacetate
Ethyl dichloroacetate
Ethyl trichloroacetate
Ethyl glycol mono acetate
Dimethyl phthalate
Pyridine
Ethylene diamine
Di-n-butylamine
β-phenyl ethylamine
Acetone
Hexane
Decane
Benzene
Toluene

There was a marked similarity in the concentrations of vapours required to activate the two species. The molar concentration of vapour required to raise the activity of flies to a standard level was calculated for each compound. A statistical technique was then used to relate these concentrations to five physical properties of the compounds (vapour pressure, water solubility, molecular volume, dipole moment and dielectric constant) which might be expected to affect the stimulation of flies through the olfactory sensilla. The results obtained by Partial regression analysis are reproduced in Table 1.

It was concluded that a compound of low vapour pressure, low dielectric constant, and high dipole moment is likely to be a good olfactory stimulant. A mechanism of olfactory stimulation of flies, initiated by the orientation of polar molecules in the membranes of the olfactory sensilla is suggested.

TABLE I

Results of Partial Regression Analysis

Factor	Partial Regression Coefficient	Variance Ratio	Percentage variability accounted for
G.morsitans			
Vapour pressure	0.743	84.16 *	91
Water solubility	0.102	0.54	
Dipole moment	-0.342	2.69	
Dielectric constant	0.759	10.73 ø	
Molecular volume	0.035	1.54	
P.terraenovae			
Vapour pressure	0.198	0.34	82
Water solubility	0.176	0.17	
Dipole moment	2.253	0.53	
Dielectric constant	1.269	4.03	
Molecular volume	-0.036	0.24	
P.regina			
Vapour pressure	2.474	1.92	89
Water solubility	0.424	0.66	
Dipole moment	-1.857	0.86	
Dielectric constant	4.147	6.83 +	
Molecular volume	0.247	1.05	

* Significant at the 0.1 per cent probability level
ø " " " 1 " " " "
+ " " " 5 " " " "

57/51 THE PERSISTENCE OF CROCEINE SCARLET DYE

D.YEO. Colonial Pesticides Research Unit, Arusha,
Tanganyika. Misc.Rep. No. 176. 1957.

The amount of an insecticide applied under field conditions can sometimes be assessed by measuring the distribution of a dye added to the formulation provided the dye used is sufficiently fast not to fade appreciably during the period between application and assessment of the deposits.

Croceine Scarlet, manufactured by the Clayton Dyestuffs Ltd., was examined for fastness under tropical conditions. Deposits on glass plates and bean leaves of 0.75% w/v solution of the dye in tap water were measured after varying exposures to direct sunlight and to cloudy conditions, and after varying periods of storage of the deposits in the laboratory.

Tests were not exhaustive but indicated that little or no loss of dye intensity occurs within one hour of application, and that deposits can be stored for several days before estimations are made.

REVIEW

MOLLUSCIDIDES IN THE CONTROL OF SCHISTOSOMIASIS (BILHARZIA)

D.J. COLWILL. Colonial Pesticides Information Service.
July 1957.

Introduction

The intention of this contribution is to survey progress in the use of chemicals against the snail vectors of schistosomiasis (bilharzia).

The disease has long been known to man. The presence of eggs of the parasite in the mummified tissues of the Pharaohs testify to its ancestry, and it was probably the "plague of Egypt" noted in Exodus, Chapter IV. It has been rated second only to malaria as the chief animal parasite disease of man and it is likely that about 5% of the world population is infected.67) It is a threat to personal health and life and to the well-being of large communities in the tropical and sub-tropical areas. Concerning the magnitude of the problems posed, which may be gauged by the valuable comprehensive surveys recently published 61), 83), 84), 87), 88), 102), 118) not least confronts the malacologist to clarify the identity, habits and ecology of the snail vectors. 91), 103), 104). It simplifies matters however on the present basis of knowledge to link, broadly, known vectors with endemic forms of the disease thus:

Disease	Countries	Principal Vector species
S.haematobium (Urinary bilharzia)	Africa and Middle East	Physopsis (Bulinus) and Biomphalaria (Planorbis)
S.mansoni (Intestinal bilharzia)	Africa, S.America and E.Indies	Australorbis
S.japonicum (Oriental bilharzia)	Far East	Oncomelania

Molluscicides are aimed against bilharzia snails which, serving as alternate hosts in a complicated life cycle of the parasite, transit the disease to man. Molluscaciding is at present the only feasible control method applicable to primitive, immature communities. Ultimately it is hoped that these people will learn to benefit from alternative methods of control inherent in civilised standards of hygiene.

Sociological aspects, disease symptoms, and other methods of control including drug therapy, have been extensively reported. 14), 17), 21), 28), 46), 59), 67), 80), 86), 92)

A. Molluscicide Research

1. Historical

The pioneer work of Kumagawa 1) and Leiper 3) demonstrating the vital mollusc link in transmission of the disease, paved the way for molluscicidal research.

The effectiveness of copper sulphate as a killer of liver fluke snails was demonstrated by Ando. 2) later, Leiper, who headed the Bilharzia Mission to Egypt during the first world war, obtained evidence of its usefulness against bilharzia snails. In 1920 Chandler 4) made a systematic screening of 13 chemicals against Limnea, afterwards extending the test to six other species, including Planorbis. Mercuric chloride and copper sulphate were shown to be highly toxic to snails. Apart from a few occasional reports, such as Khalil, 5) and early experiments in Egypt, 7) it was not until the second world war that widespread interest was aroused.

2. Against Vectors of S.japonicum 10), 12), 15), 16), 23), 26), 34), 35), 37), 43), 47), 53), 110).

The rapid growth of information on the control of amphibious snail vectors, Oncomelania spp. testifies to the activity of the Americans in this field. The contributions made by McMullen and co-workers 34), 35), 41) are outstanding. In one screening project under the aegis of the U.S. Medical Research and Development Board and University of Oklahoma they examined over 4000 chemicals. Results were substantiated by further researches at the Yamanashi Endemic Centre when the following compounds, possessing an LD_{50} of 1:50,000 or above, were reported:

2,4-Dinitro-3-methyl-6-t-butylphenol
2,4-Dinitro-3-methyl-6-isopropylphenol
2,4-Dinitro-6-phenylphenol
2-Cyclohexyl-4,6-dinitrophenol (DNCHP)
2-sec.-Butyl-4,6-dinitrophenol
4,6-Dinitro-2-amyl-phenol
2,4-Dinitro-6-capryl-phenol
2-Chloro-o-phenylphenol
2,4,5-Trichlorophenol
Tetraisopropyl monothionopyrophosphate
Dibutyl-arsenic acid
3,4-Dichlorophenyl-4-nitrobenzenesulfonamide
n-Nonyl piperidine hydrochloride
An organo-phosphorus compound (unnamed)
"DN No.1 (40% properietary mixture of DNCHP)
2-Cyclohexyl-4,6-dinitrophenol, dicyclohexylamine salt
2-Isopropyl-4, 6-dinitrophenol
"Premerge" (Alkanolamine salts of ethanol and isopropyl
  series of dinitro-o-sec-butylphenol, 54%)

Many field experiments bear witness to the effectiveness of dinitro phenolic compounds as molluscicides. In screening and field plot tests 47) 2,4,6-trichlorophenol, sodium 2,4,5-trichlorophenol and copper pentachlorophenate have proved effective against O.nosophora; also, satisfactory results have been reported using sodium PCP in Japan. 43)

Comparing the effectiveness under field conditions of sodium pentachlorophenate (sodium PCP) and the dinitrophenolic compounds, dinitro-ortho-cyclohexyl phenol (DNCHP) and its decyclohexylamine salt, McMullen at al. 35) found that these "gave similar results at the dosages used, but the first two were much less expensive.

These two chemicals cost about one half as much as calcium cyanamide, a compound which has been used in snail control in the area where these experiments were conducted. More than 18 miles of ditches were treated offering a wide variety of habitats."

Fonseca et al.53) selected 25 molluscicides effective against O.nosophora. The compounds were tested in 25 ft. ditch sectors and the active ingredients ranged from 0.6 g to 0.0125 g per sq.ft. At least 90% kill was obtained with sodium PCP, DNCHP, DNOSBP, dinitro-iso-propyl phenol, dinitrophenol and DNC.

Two requirements, considered complementary for ultimate success in the chemical control of O.nosophora, as stated by Williams et al.110) are initial reduction of the prevailing adult population to a level that would result in isolation of the survivors and repopulation control directed against the young snails. On the basis of an experiment which entailed three 6 hour applications of DNCHP (1 or 2 ppm) in irrigation water at 3 week intervals during the summer, with an interruption for 18 hours in the irrigation flow after each application, repopulation control is considered feasible in the irrigation system of Japan provided initial reduction is fulfilled.

3. Against Vectors of S.mansoni 12), 13), 24), 25), 27), 45), 52), 55), 60), 62), 68), 78), 97), 101)

Many hundreds of compounds have been screened for activity against Australorbis glabratus. Nolan and co-workers 52), 62), 78) carried out extensive screening of phenolic, mercuric and abietic type compounds. Out of 701 phenolic type compounds tested they reported that "the most effective were the highly halogenated phenols, the dinitroalkyl phenols and aryl phenols, the "bisphenol" type and the mercurated phenols." On the basis of cost and availability pentachlorophenol or its salts appeared most favourable.

Very active molluscicides were found among the mercuric compounds tested but their high toxic rating and cost overrules their general practicability. Amongst abietic acid derivatives "high molluscicidal activity at 10 ppm was shown by dehydroabietylamine, dihydroabietylamine, tetrahydroabietylamine and by Rosin Amine D and its salts. Although the results were not so marked as those given by pentachlorphenol, the abietylamines are readily available at relatively low cost and have been used in large quantities as algicides in the U.S.A."

Vallejo-Freire at al.68) tested about 20 quaternary ammonium compounds on Australorbis spp. and recorded 100% mortality at concentrations of 20 ppm or more after 48 hours contact. Investigation of mortality after withdrawal of contact shows that the retarded effect also can be considerable. Lagrange 115) and co-workers report that 'Zephirol' (dimethyl alkyl benzyl ammonium chloride) and 'Cetavlon' (cetyl trimethyl ammonium bromide) would immobilise A.glabratus in 30 minutes and prove lethal in less than 24 hours at 10 ppm. Though of relatively low mammalian toxicity the cost of these compounds is high.

Screening tests against Australorbis glabratus are carried out by the Laboratory of Tropical Diseases (U.S. National Institute of Health). Results (for test method see Appendix I), are frequently reported in the Summary Tables of Biological Tests.101)

Sodium pentachlorophenol has emerged during field tests as a favourable molluscicide against A.glabratus. Tested in a stream near Los Pena, Puerto Rico, 27) it destroyed all molluscs and their embryonated eggs for 1½ miles at 9.5 ppm based on a 6 hour flow discharge. It is frequently applied in briquette form to reduce the dust hazard. Vaughn et al.60) reporting on mollusciciding operations in an endemic area of schistosomiasis in the Dominican Republic found that one application of sodium PCP in briquette form at the rate of 15 ppm caused the disappearance of A.glabratus for six months from a flowing stream (Pana Pana) and 5 ppm destroyed these snails in a series of connected pools in a sluggish stream (Las Guamas.)

Dobrovolny and Barbosa 55) applied sodium PCP against A.glabratus and Tropicorbis centrimetralis in streams at Pernambuco, East Brazil by "drip" feeding also, preferably, by briquettes suspended in the water. Both were applied for periods up to 24 hours and concentrations in streams varied between 2 and 60 ppm. Most streams became re-infested after 2 to 4 months though repeated applications keep some streams free up to 12 months.

4. Against Vectors of S.haematobium 6), 7), 8), 9), 12), 24), 27), 29), 31), 32), 36), 63), 64), 79), 101), 106).

Copper sulphate has been used for many years in molluscicidal operations in Egypt. However because of a tendency for the chemical to precipitate and thus to become less active in certain waters, such as those of the Nile, research has been directed between finding methods of 'protecting' copper sulphate (described later) and screening other compounds.

The official U.S. Screening Agency in Egypt, the Naval Medical Research Unit No. 3 at Cairo, publish results of tests based on Biomphalaria boissyi in the Summary Tables. 101) Of the many compounds screened against these aquatic snails by various researchers, it is generally concluded that among the inorganics, the heavy metal salts of copper and mercury are active and that activity may also be found among many organo-metallic compounds containing these elements and certain phenolic, halogenated and thio-compounds.

Useful accounts of field tests are reported by Halawani 8), 9), 31), 63) against P.boissyi with several compounds including the gamma and delta isomers of BHC and with pentachlorophenol and pentabromophenol. He has reported very satisfactory results with sodium PCP ("Santobrite", "Dowicide") and dinitro-o-cyclohexylphenol (DN1, DCHP) against P.boissyi and B.truncatus. 64) The latter sprayed onto canals in aqueous solution were most effective at resulting concentrations of 5 and 10 ppm, eliminating snails for two months. Though toxic to small fish and leeches they were harmless to aquatic plants. Tests on crops showed that DCHP tended to stimulate and "Santobrite" to retard germination.

Kuntz 100) found that sodium PCP was less toxic to Bulinus and Biomphalaria than to Australorbis and concluded that dosages of 15-20 ppm for 20-24 hours were necessary. Dinitro-o-cyclohexylphenol is reported lethal to the majority of Biomphalaria and Bulinus in concentrations as low as 3-5 ppm. 36), 40)

5. Notes on Testing Procedures

Laboratory procedures for testing chemicals for molluscicidal activity are described in Appendix 1. McMullen's plate technique is preferable when screening chemicals against amphibious snails, Oncomelania spp.; an immersion method is desirable in the case of an aquatic vector.

Methods vary considerably for field testing the potential compounds that pass laboratory examination. Some experiments are conducted on a relatively extensive basis under natural conditions. Other investigations are confined to sections of ditches 10), 35) or artificial environments such as tub-aquaria 36). Bye and large it is after scaling-up from the more readily controlled artificial environments to the natural habitats of stagnant pools, flowing streams, marshes or mud flats, that the advantages or short-comings of the chemicals and techniques become evident.

The criterion for judging effectiveness is essentially per cent mortality after a stated exposure period to a known concentration (ppm) of a solution or suspension of the chemical. It may sometimes be convenient, e.g. in the case of amphibious snails, to calculate dosage rates on an area basis.

Further details are given under "Methods of Application".

B. Molluscicides in Use

1. Practical and 'Ideal' Molluscicides

Laboratory screening tests are not infallible in selecting molluscicides. For example the work of McMullen showed that certain chemicals, such as tetra-iso-propyl-monothionopyrophosphate, which are highly toxic to snails in laboratory tests may not always be successful in field practice whilst compounds, moderately active in the laboratory, like pentachlorophenol and its sodium or copper salt, may prove very satisfactory under field conditions.

A practical molluscicide must, (in addition to its ability to kill snails, preferably all stages including eggs and larvae) clearly possess properties which will enable it to stand up to the rigours in the field and yet be innocuous to other forms of life.

A molluscicide to qualify as 'ideal' must remain effective in water in low concentrations for a prolonged period of time. It must be non-toxic to man and warm-blooded animals and innocuous to fish and wild life. The material must not repel snails and it must also be cheap, readily available, easily transported, chemically stable and preferably agreeable to handle.

In practice of course all prospective molluscicides fall short of this ideal. The following are among the practical molluscicides in general use.

2. Calcium Cyanamide

A compound that has been used extensively by the Japanese. It is expensive and useful only against amphibious snails, but it is also a good fertilizer. It changes rather quickly into non-toxic compounds, but when applied once or twice yearly at the rate of 18 to 20 kg. per 1000 sq.m. the results are good.34)

3. Copper Sulphate

A chemical widely used against aquatic snail vectors. Nolan 22) reported that copper sulphate in concentrations of 20 ppm killed all Australorbis, Biomphalaria boissyi and Bulinus contortus within 24 hours. Sprayed as a 10% solution on the surface of water collections in the Bahia sector (Brazil) it was reported 92-100% effective at a dosage rate of 1:50,000 to 1:100,000 maintained for 48-72 hours. 106) Its use is keenly advocated by Mozley who obtained confirmatory evidence of its toxic value in experiments carried out at Salisbury (S.Rhodesia). Copper sulphate is relatively inexpensive and is non-toxic to higher animals but it combines too readily with organic matter and does not kill the eggs of snails. It is effective against amphibious snails only when they are in the water. Its use in running waters has been advocated by Kuntz and Wells 36) on economic grounds.

Hoffman and Zachary 48) presented data to emphasize the importance of maintaining a concentration of copper sulphate for as long as possible and their work suggests that the maintenance of low copper concentrations for an extended period may be more effective and less expensive than high concentrations by dissolving solid copper sulphate directly in canal water. The use of a 'maintenance' concentration instead of conventional periodic applications, has been adopted in the Sudan Gezira operations (q.v.). Magalhaes et al. 93) showed that the sulphate, acetate and chloride of copper have the same molluscicidal activity in equimolecular concentrations. On studying the effects of different conditions on molluscicidal activity of copper sulphate they found that mud and tartaric acid inhibit the action of the chemical considerably. The lack of persistence of copper sulphate in certain habitats was also noted by Mohammed S.Gindy 94) who investigated the various factors which could affect the concentrations of copper sulphate in natural waters. He found that Nile water has a marked effect on the precipitation of copper which is further accentuated by the presence of silt and of a mud bottom. A slight stabilizing effect can be induced by the addition of 5 ppm tartaric acid to 30 ppm solution of copper sulphate. Citric acid, however, proved to be a more effective chelating agent.

He notes: "Many factors have been suggested as causative agents in detracting from the molluscicidal potency of copper sulphate in natural waters, by removing the chemical out of solution and making it unavailable for the intoxication of snails. McMullen, Rezin and Allison (1940) discovered that copper compounds, including copper sulphate, settled down on the bottom, and did not remain dispersed throughout the volume of water. Abdel Azim and Barlow (1945) suggested that copper sulphate was absorbed by mud and weeds. Ellis, Westfall and Ellis (1946) stated that "copper is precipitated readily by carbon dioxide and carbonates, and is removed, therefore, rather rapidly from hard waters." Berry, Nolan and Gonzalez (1950) attributed the loss of copper sulphate in treated waters to the ability of organic materials and plant life to bind available copper. Nolan (1950) summed up the factors that absorb or adsorb copper, adding minerals, fatty acids, and protein in polluted waters to the list of causative factors. Pinto and Penido (1948) reported that addition of tartaric acid to copper sulphate in a ratio of 1:100 prevents precipitation of the copper salt by the bicarbonate generally present in surface waters."

A specification published by the World Health Organization (Ref. WHO/SMT/1) relates to the chemical and physical requirements of copper sulphate for molluscicidal use.

4. Copper Pentachlorophenate

Copper pentachlorophenate shows considerable promise as a molluscicide. This chemical, which is insoluble in water, can be produced in situ, by applying solutions of copper sulphate and sodium PCP from separate containers, as for example, through two compartments of an orifice box. Copper PCP first formed is of a brownish colour but on dilution the colloidal suspension imparts a pink colour to the stream. This type of treatment is unsuitable for still waters. PCP does not precipitate out, is not easily adsorbed by foreign matter and the snails are not disturbed by its presence even with high concentrations, and therefore make no attempt to escape or to retract their bodies. It is effective over a range equivalent to sodium PCP. Jove 76) regards copper PCP as a most promising molluscicide for running waters. He reported 100% control during six hours using each of its component parts at 15 ppm.

5. Other Copper Salts

Malachite (mineralised basic copper carbonate), when finely ground, is reported by Mozley, 96) who has tried out many other insoluble copper compounds, as being effective against Physopsis.

Oliveira Castro 69) showed that a suspension of 100 ppm commercial Paris Green would kill most of A.glabratus and A.nigricans in 20 to 30 minutes. Six days after commercial Paris Green had been applied at the rate of 2 g per sq. m. to running and standing waters, all molluscs were dead.

Lagrange 30) demonstrated that metallic copper had a lethal (oligodynamic) effect on Australorbis glabratus within 24 hours.

6. Dinitrophenolic Compounds

DNCHP and its cyclohexylamine salt and sodium dinitro-o-cresol were among the most effective dinitrophenolic compounds tested by McMullen. Kuntz and Stirewalt 24) found DNCHP lethal to A.glabratus and B.contortus within 24 hours at 2 and 3 ppm respectively, whilst Kuntz and Wells 36) found it to be lethal to the majority of Biomphalaria and Bulinus in concentrations as low as 3 to 5 ppm. The effectiveness of DNCHP is apparently not prejudiced by the presence of aquatic plants and unusual quantities of organic materials, and the chemical has a residual killing power lasting up to four weeks after application. Its ovicidal properties surpass those of copper sulphate at much higher concentrations. 40)

DNCHP can be applied easily to any volume of water by non-trained personnel and without the use of complicated or expensive equipment. The main disadvantage is its high cost, which is also the limiting factor with its very effective cyclohexylamine salt. Other dinitro compounds, such as dinitro-o-cresol and dinitro sec butyl phenol are eliminated for field use on account of their corrosive properties or mammalian toxicity rating.

7. Pentachlorophenol and Its Sodium Salt

These compounds, for molluscicidal use, are covered by specifications WHO/SMT/2 and WHO/SMT/3 of the World Health Organisation. The compounds are poisonous to fish but do not harm invertebrates and they are becoming widely used where copper sulphate fails owing to vegetation or organic matter. Their

other than snails
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employed.

ability to destroy mollusc eggs, not evident in some early experiments, 49) has now been established.102) Characterised by relatively high efficiency they have been widely used at concentrations varying from 5-15 ppm.

Snails are particularly irritated by sodium PCP and they will try to escape from the molluscicide by leaving the water. When treating running streams, therefore, it is advisable to use lower concentrations (5-10 ppm) or many snails will withstand the treatment. Sodium PCP is generally applied in pellet or briquette form (commercially available) since the dust is very irritating to the nasal mucosa. It does not precipitate out nor is it adsorbed as easily as copper sulphate. For that reason it will prove effective for distances from three to four times as long as copper sulphate. On the basis of field tests carried out by Hunter et al.43) with sodium PCP in Japan a five year plan was promoted for the control of snails (*O.nosophora*) in the entire endemic area of Kyushu. Dobrovolny and Haskins 56) found that various earthy materials reduced the concentrations of sodium PCP particularly when high proportions of mud were present. This observation is borne out by Pereira and Mendonea 70) who, whilst treating running streams in Minas Gerais, Brazil, noted that though 10 ppm were present up to a distance of 2,900 metres after 48 hours, there was no increase in range after a further period. Wright and Dobrovolny 97) noted the rate of disappearance of the chemical whilst treating streams near Recife, Brazil. The most effective concentration was 10 ppm. They also state that 2 ppm for 40 hours was about as effective as high concentrations for 8 hours. It appears that effects can be minimized by not stirring the mud during treatment. Direct sunlight has also been found to act as an adverse influence in shallow open waters. 56) NaPCP is toxic to fish even at 6 ppm, but it does not appear to affect aquatic plants.100)

PCP and its salts are also effective against amphibious snails but less so that some of the dinitro-phenolic compounds.

8. Molluscicides of Bacteriological Origin

A culture of *Bacillus pinotti* (also known as B.E.T. or bacilo de esporo terminal) has been applied in Brazil against *Australorbis* spp. According to Dias 71) large amounts of culture media (ordinary 1% peptone water or meat extract broth) may be conveniently prepared in drums of 200 litre capacity. Perfect sterilisation is not necessary; it is sufficient to boil the medium for a few minutes then adjust pH to 7.2 to 7.4 and inoculate heavily with pure B.E.T. culture after cooling to 50° or 60°C; incubation at 37° is not necessary. Good cultures have been prepared with only moderate heating. On one occasion spray treatment of three large snail habitats resulted in the death of 155,502 snails. On another, 307,197 dead snails (A.glabratus) were recovered from a pond during eight months following treatment. This method has also been tried in Egypt.79)

9. Molluscicides of Vegetable Origin

Mozley 96) refers to the molluscicidal properties of the saponin-containing plants Balanites, Sapinidus and Swartzia. The juice of the "paraparo" berry (Sapindus saponaria) is recommended for use in Venezuela where it is cheap, plentiful and lethal to Australorbis glabratus at a concentration of 1:10,000 over 10 days.58)

Teesdale 72) reports that in the Coast Province of Kenya some preliminary experiments are being made with the roots of Neorautenenia pseudopachyrhizus (which also contain saponin). Previous experiments with indigenous fish did not show much promise.

10. Antibiotics as Molluscicides

Seneca and Bergendahl77) tested 14 antobiotics as molluscicides against A.glabratus. Thiclutin (from Streptomyces albus) was the most effective, being lethal at 0.25 ppm in a 12 hours exposure. It is, however, expensive to manufacture.

Rimocidin (from S.rimosus) was lethal at roughly 4 ppm in a 24 hour exposure period. It shows promise as a molluscicide and is moreover a by-product in the manufacture of oxytetracycline and is therefore easy and cheap to manufacture.

C. Application of Molluscicides

1. General

Various means exist for applying molluscicides in solid, liquid or formulated media. In the solid state chemicals may be in the form of a dust, or bait, or contained in bags which are immersed in infested waters. In solution, they may be sprayed onto the surface of the area to be treated or, in the case of running waters, metered into the stream through some suitable device such as a dip tube or constant orifice box. In a few cases the active material may be produced in situ by reacting calculated amounts of the component solutions, e.g. copper pentachlorophenate.

The amount of molluscicide to be applied against aquatic snails is calculated from the estimated volume of water, if still, or the rate of flow, if moving. A 90 notch measuring weir can usefully be set in small channels. In larger channels estimations of flow are based on the surface velocity and cross section. Vegetation and debris which may inhibit the success of the treatment should be removed. Disturbance of mud, silt, etc. which may render the treatment less effective is usually avoided. Extra attention may be necessary where rocky habitats are encountered. The fact should also be borne in mind that the activity of some molluscicides has been shown to increase with rise of temperature.36), 38), 48).

Under certain conditions it is probable that penetration and hence toxic effect can be improved by the addition of surfactant. Tergitol NPG was most effective of 23 non-ionic dispersing agents tested by Ritchie et al.,98) among which other alkyl aryl polyethylene glycol ethers, polyethylene glycol 600 or 400 and an alkyl aryl polyoxyethylene derivative were found suitable. Aerosol OT 100% (Dioctyl sodium sulphosuccinate) was the most satisfactory of several wetting agents tested.95)

The effectiveness of treatment should be assessed by observations on the number of snails present before and after treatment. For convenience cages containing live snails may be spaced out at regular intervals downstream. Determination of the active principle (ppm) can be made from samples of the effluent drawn at corresponding points. Methods for the chemical and biological estimation of widely used molluscicides are given in Appendix II.

In the following section various methods of applications are described. Choice to be followed is largely governed by the nature of the snail habitat, availability of labour and economic considerations.

2. Bag Method

Bags containing the molluscicide are suspended in stream so that the chemical can be gradually leached out by the flow of water. The fabric of which the bag is composed controls the rate of release of chemical. One or more bags, frequently made from canvas or twill, are used. The "dunking" of bags is also practiced where labour is cheap. (See also Sudan Gezira operations.)

3. Dusting

Mozley has described the sprinkling of malachite compositions by hand. Robinson,65) reporting on snail control in N.S. Wales using copper and sodium pentachlorophenate dusts, indicates that at about 7½ lbs/acre these chemicals, dispersed by knapsack duster, were more effective than copper sulphate but acted more slowly.

4. Spraying

Concentrated solutions of molluscicides can be applied readily from knapsack or mechanical pressurised sprayers. Good cover is obtained and it is one of most widely used methods. To avoid the inconvenience of transporting stock solutions Veloso50) employed a collapsible canvas tank containing copper sulphate solution (0.1%) which was sprayed at 300 lbs. pressure.

Jove76) states that marshy areas in Venezuela are treated by means of knapsack sprayers or with a motor pump if of great extent. The sprayers are filled from 100 litre casks set up around the periphery of the area to be sprayed. The content of one sprayer, 15 to 16 litres, will usually cover about 150 sq.m. and the operation of spraying takes from 7 to 10 minutes. Drainage ditches are treated by means of knapsack sprayers. A length of about 200 metres is sprayed with the content of one sprayer, taking from 7 to 10 minutes. Ponds and large marshy areas are sprayed with a motor pump. Spraying is not carried farther than ten metres from the shore, since the snails are not usually found in deeper water. In marshes, however, the total area is covered. If necessary, both the cask and pump are carried towards the central parts of the marsh.

5. Impounding, etc.

On comparing various procedures Fonseca et al.53) found that impounding with DNCHP gave 90-99% mortalities whilst continuous flow gave 90% and flooding 57-100%.

6. Metering

Various means have been devised to introduce automatically under favourable circumstances, consistent and reproducible amounts of molluscicide. Constant flow apparatus, briquettes and pellets are among these.

(a) Constant Flow Device. Haskins and Dobrovolny 54) describe an apparatus consisting of a metal or wooden barrel, 100 to 200 litre capacity, with a copper tube 2 to 3 mm diameter inserted through the air-tight top as a vent pipe and having a valve inserted in the side of the barrel 3 to 5 cm above the bottom. It requires little attention and gives a constant and reproducible rate of flow of solutions of molluscicides. The flow rate is regulated by varying the distance between the bottom of the vent pipe and the level of the outlet valve or by varying the size of the valve opening.

(b) An Automatic Molluscicide Dispenser for Use in Flowing Water. 109). An apparatus consisting basically of a measuring weir coupled to a float activated siphon has been successfully operated by unskilled personnel in Puerto Rico. It is estimated that treatment of an endemic area can be carried out in one third of the time previously required and at approximately one fourth the previous cost. Elimination of the tendency to over- or under-dose has resulted in improved molluscicidal effectiveness and the mechanical reliability of the dispensers has been demonstrated for tenfold variations within flow rates of 0.08 cfs to 2.0 cfs for a 24-hours period. Maintenance consists of an occasional flushing with chloroform to remove deposits. The principles of construction are discussed in the original paper.

(c) Constant Orifice Box. A two compartment orifice box is described, 76) which feeds material at a constant rate. The boxes are made of wood and coated with paraffin on the inside. Each compartment is about 50 cm long, 18.5 cm wide and 25 cm high. Each is provided with a $\frac{1}{2}$" inlet bronze valve and copper float. On the bottom of the anterior end of each compartment there is an opening through which is placed a bronze nipple. To each of these nipples a $\frac{3}{8}$" flexible rubber hose is connected. Each rubber hose is provided with a screw clamp (Hoffman type clamp). The compartments are fed from stock solutions maintained in casks. To prevent sediment forming in the copper sulphate solution, with risk of clogging, a small amount of dilute sulphuric acid is added. During copper sulphate treatment the compartments are filled with equimolecular solutions of copper sulphate and tartaric acid (to prevent precipitation) and released in the ratio of 5:1. For copper pentachlorophenate treatment equal volumes of equimolecular solutions of copper sulphate and sodium pentachlorophenate are released from each section respectively.

/er (d) Briquettes, etc. At the Bilharzia Research Laboratory, Salisbury, Rhodesia, a plasti~~c~~ brick containing sodium pentachlorophenate is under test. The bricks are submerged two feet under water whence the chemical seeps out destroying snails and their eggs within a radius of several yards.

Methods of controlling the rate of additives of molluscicides to water are being evaluated at Colonial Pesticides Research Unit, Porton.90). The following have been described:

Briquettes made from a mixture of cement or plaster and the molluscicide. Their main disadvantage was that if the hardening properties of the carrier were not to be affected the percentage of molluscicide had to be kept low. This especially applied to an alkaline material like sodium pentachlorophenate.

Pellets made from the molluscicide bound with a thermosetting resin. These were easily made and were stable in water but the leaching rate of the chemical was dependent upon the concentration left in the pellet and therefore decreased with time.

Films of plastic separating the molluscicide from the water. These appear promising as their action in controlling leaching should be independent of concentration although the films so far tested have either been too porous or not porous enough.

D. Molluscicide Campaigns

Large scale operations being carried out in several parts of the world including Egypt, Rhodesia, Sudan, Swaziland and Venezuela are briefly reviewed.

1. Egypt 7)

The snail destruction section of the Ministry of Public Health was set up in 1941. There are now under its surveillance over 2,000,000 acres of a perennially irrigated area containing over 100,000 kilometres of streams. A general survey based on the numbers of snails netted at suitable intervals is carried out each spring and streams requiring treatment are, as far as possible, closed and cleared of vegetation.. Each is then dosed with copper sulphate at an initial concentration of 15-20 ppm and left for 2-3 days. Margins of the larger canals only are treated.

2. Rhodesia 57)

Watering courses in an area of nearly 3,000 sq. miles, embracing the Mazoe Valley and N. Mashamoland, are treated between April and October ("Dry season") when the risk of infection is most likely. Natural streams and water courses then slow running and aften forming a series of stagnant pools provide an excellent milieu for the vector snails (Physopsis spp.). Treatment is carried out by teams, seasonally released from anti-malarial duties, consisting of three men equipped with stirrup pump, bucket (bitumen-lined) and copper sulphate stock. Application is concentrated on places where contact between vector snail and human is likely (e.g. village watering places, laundry sites, road and path crossing of streams; even entire streams, when closely related with human activities. Where waters are too broad to be covered by the natural throw or the pump, working from all sides, no attempt is made to treat the middle, on the assumption that snail activity is negligible so far from the shore. No details of the frequency of retreatment are given in the literature. In spite of the apparent crudity of the method, it is claimed that analysis of treated waters shows fairly constant dosages of between 10 and 30 ppm of copper sulphate to have been applied.

3. Sudan 73), 74)

Experiments carried out prior to 1950 established that a dose of 30 ppm copper sulphate was required to give a satisfactory kill of Physopsis and Biomphalaria spp. in irrigation channels in the Gezira. These dosages had to be given at intervals of not less than three months, on account of reinfestation. A method which has superseded this retreatment is the application of continuous "maintenance dose" of $\frac{1}{8}$ part per million (0.125 ppm) of crystalline copper sulphate, following upon a 30 ppm "eradication" dose. The continuous treatment of running water is carried out by suspending bags of the chemical in the current near to water control points, where the amount of copper sulphate to be added can be calculated from the water flow.

An experiment on a 70 km branching system of canals described by Hamid Sherif el Din and El Hadi el Nagar, gave virtually complete control of snails during the period September 1953 to December 1954, with some reduction of water weed growth. The scope of the experiment has now (1956) been enlarged to include treatment of most of the canals of the Gezira as a routine measure. The 1954-55 programme of the Ministry of Health included provision for treatment of the Northern half of the Gezira and the 1955-56 programme envisaged its completion to cover the whole. Nearly 5,000 kilometres of canals supplying 6,000 sq. miles of agricultural land will eventually be protected.

Traps, which provide an attractive milieu for snails and also filter out egg-masses, vegetation, etc. have been designed and are being used successfully by Markowski 105) in the Sudan Gezira. The traps consisting of rectangular box-like iron frames 6' x 4½' x 3' with cross pieces supporting single palm leaves arranged to form a filtering screen, are set across the width of a canal. The traps which had latterly been treated weekly with copper sulphate have performed most effectively. Hundreds of snails are stated to have been recovered during 3 months observation with virtually complete elimination from waters downstream.

4. Swaziland 66)

An initial experiment, using copper sulphate was started in 1952, confined to the Msimneni catchment area - about 20 sq. miles of country. The area of the experiment has now grown to 50 sq. miles, though operations in 1955 were erratic on account of labour and other difficulties, and only part of the area was treated. Copper sulphate at approximately 30 ppm is applied, on the Rhodesian system, the aim being to make four applications per annum.

5. Venezuela 76)

The disease is present in the north central section of Venezuela involving an area of approximately 1,600 acres. Against the vector *Biomphalaria guadeloupensis*, commonly known as *Australorbis glabratus*, the Ministry of Health are campaigning with copper sulphate, sodium pentachlorophenate and copper pentachlorophenate. Their results are summarised in the following table.

Molluscicide	Concentrations toxic to snails	Dosage used in Venezuela	Remarks
Copper sulphate	2 ppm 48 hr. period	100 ppm 3 hr. period (+ 20 ppm tartaric acid)	More concentrated dose used for economic reasons. 20% tartaric acid added to prevent precipitation in alkaline water. Impaired by organic matter (absorption)
Sodium PCP	above 2-3 ppm 24 hr. period	5 ppm 24 hr. period	Irritating even in low concentrations. Tendency for snail to leave water. No reliable test available for estimating concentration.
Copper PCP	above 1 ppm 100 hr. period	15 ppm copper sulphate + 15 ppm sodium PCP 6 hr. period	Apparent 100% effectiveness reported. Disadvantages of component chemicals eliminated.

E. Prospect

In the foregoing pages endeavour has been made to trace the growth in the screening, technique of application and use of molluscicides. Despite the present choice of chemicals there is need for developing persistent molluscicides possessing activity measurable over months rather than weeks, with the object, primarily, of reducing costs and improving efficiency for large scale campaigning. There is also another reason: many aquatic snails may at present survive treatment of a habitat through being left in the grassy fringes of sluggish water courses during the dry season. In the absence of continuous or further application of the chemical these aestivating snails can escape control when rain washes them back into the water.

Laboratory trials have already been initiated into the possibility of extending the period of molluscicide activity of present chemicals through formulation 108). Five candidate materials were tested including copper oxychloride, copper pentachlorophenate, BHC (15% gamma) paste, 15% pentachlorophenol emulsifiable oil and colloidal copper. The best results were obtained with the PCP emulsifiable oil which showed a residual action of 2-3 months irrespective of mud being present; favourable results were also reported for the BHC paste and colloidal copper. It is of interest to note that colloidal copper ("copper oxydule") was reported several years ago to have given "substantial and lasting results" at Costermansville on Lake Kivu in the Belgian Congo, when it remained lethal to molluscs for over 30 days at 1:800,000.107)

A recent publication by a W.H.O. Study Group 104) confirms the need for developing molluscicides with a longer period of activity. They suggest further examination of compounds based on elements known to be inimical to snails in minute quantities e.g. copper, nickel and zinc. They also speculate on the possibility of adding attractants to insoluble toxic materials.

Work will however continue to proceed on a trial and error basis until gaps in present knowledge are bridged. For instance, concerning the mode of action of molluscicides, it is considered that some compounds affect respiration by causing mollusca to retreat within the shell whilst others are probably true inhibitors. 111).

It is of course not possible, or desirable, to foretell the problems that lie ahead but it has already been hinted that the continued use of molluscicides may produce resistant species. 116)

APPENDIX I

Methods of Screening Molluscicides

1. Screening Agency: U.S. Naval Medical Research Unit No. 3. Cairo.

Technique: Compounds from 0.16% stock solution (w/v) in acetone, 95% alcohol or dioxane are diluted to an initial concentration of 16 ppm (w/v) in 250 cc. canal water (pH 8.0-9.0). Duplicate lots of five snails, Biomphalaria boissyi, are placed in this solution for 24 hours at 70-80°F followed by 24 hours in fresh canal water at the same temperature. Results are based on the death or recovery of the snails following the test period and by comparison with five untreated snails.

2. Screening Agency: National Institute of Health, Bethesda, Maryland.

Technique: Compounds from 1 or 0.5% stock solution in acetone or alcohol diluted to 10 ppm in 250 cc. of dechlorinated tap water aerated by a slow stream of air. 5 Australorbis glabratus snails exposed for 24-48 hours at 78° - 80°F. After treatment the snails are transferred to clean water. Results are based on the death or recovery of snails following transfer and on comparison with 5 untreated snail controls.

3. A Plate Method of Screening Chemicals Against Amphibious Snails.

(McMullen, D.B. (1949). J.Parasitol., 35, (6 Sect.2), Suppl. p.28).

A dried filter paper, impregnated with 2 cc. of 1:10;000 solution of the chemical is placed in a petri dish. Snails are placed in the centre of the paper and 3 cc. of water are added. This method, which overcomes the disadvantages associated with submerging amphibious snails in water diluted with chemicals, enables irritant, toxic and residual effects to be observed.

APPENDIX II

Analysis of Molluscicides

1. Detection of Copper

The presence of copper in concentrations as low as three parts per million can be detected by the use of potassium ferrocyanide as a reagent. The colour, due to the formation of copper ferrocyanide, varies in density with the amount of copper present in the water. This can be measured rapidly in the field by the simple and effective apparatus (described and illustrated) named a "copper colordensitometer."

(See V.de V. Clarke, F.A. Goodlife. J. Trop.Med.Hyg., 1955 58, (4), 80-5. Control of bilharziasis: A simple device for measuring copper concentration in natural waters treated with copper sulphate.)

2. Detection of Sodium and Copper Pentachlorophenate (Field Test).

The presence in water of the molluscicides sodium and copper pentachlorophenates in concentrations of 1 to 100 parts per million can be rapidly ascertained by placing 5 ml. of the water to be tested in a 16 by 150 mm. screw-capped culture tube and adding 1 ml. of bicarbonate-methylene blue reagent and 5 ml. of chloroform. The tube is then tightly closed and shaken vigorously for 15 seconds. The tube is then placed upright. As soon as the layers separate the upper layer is definitely blue if the sample contains 10 ppm or less of pentachlorophenate; when the concentration is greater than 10 ppm the upper layer is colourless or very pale blue. For samples containing 25 ppm, 50 ppm, 100 ppm an additional 1 ml, 2 ml, and 4 ml of the reagent must be added to the respective samples before the upper layer becomes a definite blue. The tests should be read within 30 minutes as the colour then changes to pink. The method has 20% ± error in the range of 5 to 100 ppm and ± 1 ppm below 5 ppm.

(Haskins, W.T. Anal.Chem., 1951, 23, 1672-1674).

3. Quantitative Determination of Copper

Dithio-oxamide is a sensitive and highly selective reagent for the determination of copper; an alternative reagent, sodium diethyldithiocarbamate, reacts with lead or zinc and its use involves a separation by extraction. However, the dithio-oxamide method, as usually specified with acetate buffer, is seriously affected for visual determinations by iron, which with the acetate gives an interfering orange colour. As recommended by West and Compere, malonate was used in place of acetate.

Dithio-oxamide Method

Reagents. All reagents should be of recognised analytical quality.

Ammonium acetate solution - Dissolve 20 g of ammonium acetate in distilled water and dilute to 100 ml.

Malonic acid solution - Dissolve 20 g of malonic acid in distilled water and dilute to 100 ml.

Gum acacia solution - Dissolve 1 g of gum acacia in distilled water and dilute to 100 ml. Stabilise the solution by boiling it and adding thymol.

Dithio-oxamide solution - Dissolve 0.2 g of dithio-oxamide in 100 ml of 90 per cent ethanol.

Standard copper solution - Dissolve 0.1964 g of clear crystals of copper sulphate, showing no signs of efflorescence, in water, add sufficient hydrochloric acid to make the final acidity about 0.1 N and dilute to 500 ml. Dilute 10 ml. of this stock solution with 0.1 N hydrochloric acid to 100 ml, so that -

1 ml = 0.010 gm of copper.

Procedure. From the prepared solution take an aliquot containing between 0.01 and 0.2 mg of copper, and reduce the acidity by adding ammonia solution. As care should be taken not to precipitate any iron, it is best to leave the solution slightly acid. Add 1 ml. of malonic acid solution and 5 ml. of ammonium acetate solution; this should bring the pH value to approximately 5.2. Add 1 ml. of gum acacia solution and finally 0.5 ml. of dithio-oxamide solution, mixing well after each addition. Dilute to 50 ml., mix and set aside for 20 minutes. A blank determination on all reagents used, including those in the preliminary treatment, should be made in the same way as for the sample.

Compare with standards similarly prepared, in Nessler tubes or a visual colorimeter; a commercial comparator is available, in which permanent glass colour discs are used, but these must be re-calibrated, since the procedure described above is a modified one that permits a greater tolerance to iron. Alternatively, determine the optical density at about 650 mμ in a photo-electric absorptiometer, and read the amount present from a calibration curve prepared by treating known amounts of copper in the same way as the sample.

(Christie et al. Analyst, 1957, 82, (974), 336-342).

4. Quantitative Determination of Sodium and Copper Pentachlorophenate.

A spectrophotometric modification of the field test method noted above is based on the chloroform soluble complex formed between tetra- and pentachlorophenates and safranin-O in bicarbonate-buffered samples. It is stated to be suitable for determining 5 to 50μ gms in a 5 ml. sample.

Procedure. A 5-ml. sample of an aqueous solution containing 5 to 50 microns of the tetra- or pentachlorophenate is placed in a glass-stoppered for screw-capped 16 x 150 mm. tube, 5 ml. of chloroform are added and followed by 0.5 ml. of saturated sodium bicarbonate solution and 0.5 ml. of 0.02% safranin-O solution. The tube is closed and shaken vigorously for 15 seconds. After allowing about 5 minutes for the layers to separate and become clear, 3 to 4 ml. of the chloroform layer are removed from the tube with a capillary pipette and transferred to a 10-mm. cuvette which is loosely stoppered to prevent excessive evaporation. (The author used Corex cells and covers with a Beckman DU spectrophotometer). A blank determination is run at the same time using 5 ml. of water and the same reagents. The optical density of the unknown is determined in the region of 520 to 550 $m\mu$ after setting the instrument to zero with the blank. The concentration is then obtained from a calibration curve prepared from known concentrations of the tetra- or pentachlorophenate in question.

(Haskins, W.T. Anal. Chem., 1951, 23, 1672-1674)

5. Bio-assay Determination of Sodium Pentachlorophenate.

The method, suitable for field use, is based on the mortality rates of the guppy fish, *Lebistes reticulatus*. The mortalities in the sample for analysis are compared with those in natural water containing a known amount of the molluscicide. The concentration is established by reference to standard semi-logarithmic mortality curves prepared for dosages ranging from 2 ppm to 25 ppm.

(Klock, J.W. Amer. J. Trop. Med. & Hyg., 1956, 5, (2), 286-289)

6. A Colorimetric Micromethod for Determination of Pentachlorophenol.

Pentachlorophenol is oxidised with HNO_3 to chloranil. This is treated with tetrabase (tetramethyl-p-diaminodiphenylmethane) and the blue compound is determined colorimetrically. The method is reliable for amounts of pentachlorophenol between 20 and 200 μg/ml of solution in the colorimeter tube. With a spectrophotometer the method is more sensitive and a greater precision in measuring is possible. The lower limit of the spot test is 2.5 μg. The absorbance was determined at 600 and 415 $m\mu$. The method is suitable for biochemical and toxicological studies.

(Erkhama, J., Laamanen, A Suomen Kemistilehti, 1956, 29 B, (2), 37-39) (in English). Abs.Chem.Abstr. 1956, 50, (22), 16566).

APPENDIX III

Specification for Molluscicides

(Extracts from "Specifications for Pesticides", 1956, W.H.O. Geneva).

1. Copper Sulphate

The material shall comprise essentially copper sulphate pentahydrate in the form of blue or bluish-green crystals free from visible inpurities and hard-caking properties.

Copper sulphate pentahydrate content % by wt.	98.0 (min.)
Acidity % by wt. calculated as H_2SO_4	0.1 (max.)
Water-insoluble material % by wt.	0.2 (max.)

2. Pentachlorophenol

The material shall comprise essentially pentachlorophenol in the form of dark greyish flakes with a phenolic odour and substantially free from dust. The material shall be free-flowing and free from extraneous impurities or added modifying agents.

Pentachlorophenol content % by wt.	96.0 (min.)
Crystallizing-point	174°C
Alkali-insoluble material % by wt.	1.0 (max.)

2. Sodium Pentachlorophenate

The material shall comprise essentially sodium pentachlorophenate in the form of a greenish-white powder free from dust and extraneous impurities.

Pentachlorophenol content % by wt.	75 (min.)
Free alkalinity % by wt. calculated as NaOH	0.3 - 1.0
Loss on drying % by wt.	8.5 (max.)
Crystallizing-point	172°C
Water-insoluble material % by wt.	1.0 (max.)

APPENDIX IV

Various Compounds of High Molluscicidal Activity against Aquatic Vectors.

Compounds rated 100% Lethal to Biomphalaria boissyi at < 2 ppm. (C.B.C.C. Summary Tables) 101)

Compound	Concentration ppm
Bis diphenyl methyl ether	0.5
Phenyl mercuric acetate	1.0
Phenyl mercuric butyrate	2.0
Phenyl mercuric propionate	2.0
Di-phenyl mercury	2.0
Di-n-propyl mercury	2.0
∞ -nitro stilbene	2.0
5-bromo-2-diphenylamine	2.0
S-phenyl methyl thio carbamyl hydrosulphamine	2.0
2.4-dinitrophenyl dimethyl dithio carbamate	2.0
Bis di methyl thio carbamyl disulphide	2.0
Sodium di-methyl dithio carbamate	2.0
Ferric di-methyl di-thio carbamate	2.0

Note: Under similar test conditions pentachlorophenol (2 ppm) caused 80% mortality.

Compounds Rated 100% Lethal to Australorbis glabratus at ≤ 3 ppm. (tested by Nolan et al.) 52)

Bis (2-hydroxy-3,5,6-trichlorophenyl) methane
2,4-Dinitro-6-sec-butylphenol
2,4-Dinitro-6-cyclohexylphenol
2,4-Dinitro-6-cyclohexylphenol,dicyclohexylamine salt
2-Hydroxyphenylmercuric chloride
4-Hydroxyphenylmercuric chloride
4-Hydroxyphenylmercuric thiocyanate
2,4-Dichloromercuric phenol
Pentachlorophenol
2,4,6-Triiodophenol

APPENDIX V

Some Other Chemicals of Current Interest Tested as Molluscicides Against Aquatic Vectors.

	Compound	Test Mollusc	Description of Test	Results	Reference in Text
METAL SALTS					
Barium:	Barium chloride	B.contortus	Laboratory	Toxic at 1:70,000	117
		P.glabratus	Laboratory	Toxic at 1:90,000	117
	Barium nitrate	B.contortus and P.glabratus	Laboratory	Toxic at 1:50,000	117
Copper:	Copper 6 methyl 2,4 heptanedione	B.boissyi	Laboratory	100% mortality at 8 ppm	101
	Copper oxalate diamino complex	A.glabratus	Laboratory	100% mortality at 10 ppm	101
Iron:	Ferrous Sulphate	P.guadelupensis	Laboratory	Effective at 1:100,000 Addition of tartaric acid appears to increase its effectiveness	114
	Ferric Sulphate	B.contortus and P.glabratus	Laboratory	Toxic at 0.5 gm per cent. Some snails unaffected. Non toxic to fish.	116
	Ferric Chloride	B.contortus and P.glabratus	Laboratory	Toxic at 0.065 gm per cent. Some snails unaffected. Non toxic to fish.	116
Lead:	Lead arsenate (mixed with wheat flour and a bait)	A.glabratus	Field test-Brazilian coast Nr. Sao Paulo	Reported successful among substances tried.	113

	Compound	Test Mollusc	Description of Test	Results	Reference in Text
Nickel:	Nickel pentachlorophenate	B.boissyi	Laboratory	80% mortality at 2 ppm	101
	Nickel cyclohexane propionic acid	"	Laboratory	50% mortality at 10 ppm	101
	Nickel 2 ethyl hexanoic acid and Nickel butyrate	"	Laboratory	20% mortality at 10 ppm	101
	Nickel salts such as: cinnamate, citrate, selenate, sulphamate, valerate, 2,4-D and ethylene bis dithio carbamate	"	Laboratory	Ineffective at 10 ppm	101
Tin:	Tin tetra propyl	B.biossyi	Laboratory	40% mortality at 4 ppm	101
	Tin tetra ethyl	"	Laboratory	Ineffective at 10 ppm	101
Zinc:	Zinc chloride	Planorbis and others	Laboratory	Effectiveness not marked	4
	Zinc sulphate	Planorbis and others	Laboratory	Effectiveness not marked	4
	Zinc formaldehyde-sulphoxylate	Physopsis	Field test S.Rhodesia	Probably toxic above 450 ppm	6
OTHERS					
β-Bromoethyl bromo acetate		B.boissyi	Laboratory	95% mortality at 4 ppm	101
Ethyl chloracetate		A.glabratus	Laboratory	Toxic at .0001M	13
Metaldehyde (mixed with wheat flour and a bait)		A.glabratus	Field test Brazilian coast Nr. Sao Paulo	Reported successful among substances tried	113
∞-Nitro-styrene		A.glabratus	Laboratory	90% mortality at 10 ppm	101
Orthidichlorobenzene ("Chlorben")		Egyptian snails	Field Test Egypt	Kills snails and aquatic plants. Potential danger to rice crop.	112

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(xxii) MISCELLANEOUS ITEMS ON PEST CONTROL FROM THE COLONIAL TERRITORIES

(ABSTRACTS FROM ANNUAL REPORTS)

Bermuda

Land Crab (*Gecarcinus lateralis*): Effectively controlled by placing a teaspoonful of bait, containing about 2% DDT or dieldrin in moist, salted bran, in the mouth of each crab-hole.

Cedar Scale (*Carulaspis minima* Targ): Control was effected by applying malathion 56% emulsifiable concentrate at the rate of 3 pints per 100 gallons water.

Cyprus

Mediterranean Fruit Fly (*Ceratitis capitata*): It was found that a reduction of the concentration of dieldrin from 0.1% to 0.075% did not materially reduce its effectiveness and that spraying alternate rows of trees in large citrus groves with a 0.1% dieldrin solution was almost as effective as spraying every tree in the grove.

Citrus Pests: An experiment was begun at Lapithos to evaluate various materials and treatments in the control of the citrus bud mite on lemon trees. The materials being used are white oil, chlorobenzilate, R-6199 (Plant Protection) and 4536 (Bayer, "Metasystox"). Very encouraging results have been obtained so far with 4536 applied as a trunk treatment just prior to the spring flush of growth.

An experiment was carried out on grapefruit at Fassouri (Limassol district) with various treatments aimed at the combined control of *Aonidiella aurantii*, Mask., *Myelois ceratoniae*, Zell., *Cryptoblabes gnidiella*, Mill., and *Pseudococcus citri* Risso. Best results were obtained with a combination of parathion-malathion spray applied twice on July 18th and September 13th. The performance of oil alone, under the conditions prevailing at Fassouri, was very unsatisfactory.

Kenya

Coffee Leaf-Miners (*Leucoptera* spp.) 95-100% control of leaf-miner (*Leucoptera coffeella* Guer and *L. caffeina* Washb.) is reported using diazinon. Spray treatment has been directed against the larvae in their mines.

Nigeria

Yam Beetle: Most effective insecticide tested was a 0.45% gamma BHC dust which decreased average damage by 28% and increased average yield by 46%. The yield increases were better than in previous years but the percentage decreases in damage were not so good.

Seychelles

Citrus: The "Eddy wasp" parasite of citrus black fly had, by the end of the year, been distributed by the Department (or in some cases had spread unassisted) to nearly all parts of Mahe. Where the parasite had been at work for some nine months or more entirely satisfactory control of the pest was achieved and trees formerly black and sickly with the pest and the fumagine resulting from it were almost completely clean.

Buffalo fly: Complete control - indeed, eradication as far as could be determined - was achieved in the trial on North Island by spraying toxaphene.

Coconuts: Progress of *Scolia ruficornis* (introduced to North Island by the Department) was studied and this parasite of the coconut pest *Oryctes monoceros* was found to have become firmly established in a large "plateau" of open-planted coconuts where the use of uncovered manuring pits was practised. The wasps were not seen in heavily shaded areas, nor in areas where the soil was impoverished and the pest confined its breeding to coconut trunks. A survey was made on Cerf Island in the release-area of the Nitiluid predator *Rhizophagus dispar* obtained from the Commonwealth Institute of Biological Control in 1955 as a possible egg-predator of *Melittomma insulare*. No recovery could be made.

Tanganyika

White Coffee Borer (*Anthores leuconotus* Pasc.); Satisfactory control measures have been worked out using 0.5% dieldrin.

Electric Fencing: Following the successful use of electric fencing by the Game Department Biologist against large game, including elephant, there has been a growing interest in this method of protection. It has been successfully used against elephant in sugar estates in the Eastern Province, with some success against hippo in rice areas, but so far trials against pig in the Western Province have not proved successful. The chief drawback to the use of electric fences is the considerable cost of maintaining clean ground below the wire. Where cultivators are willing to use their initiative fences have been built which have been quite effective against pig.

Quelea Control: Control operations at two nesting sites, using flame throwers, were very successful, an estimated thirty million birds being destroyed. One colony covered 800 acres and twenty million birds were killed there. A notable feature of the early invasions of the Northern Province was that the flocks were composed of 90 per cent old birds; in previous years flocks have contained up to 90 per cent young birds. This may be an indication of the effect of these heavy attacks on nesting colonies. The locally devised flame-bomb method was used for control in a number of roosts when the birds had reached the wheat areas. Trials were made for the first time using the technique of aerial spraying with parathion developed in the Union of South Africa. These trials were made on a 70-acre nesting site. The trials were not made at the best time, after dark, because of practical difficulties but they gave a fair measure of success, some 75 per cent of the birds being killed.

Uganda

Tsetse Control: The 1956 Annual Report of the Tsetse Control Department, Uganda Protectorate, reviews the progress made in the past year, and includes some information on the development of a single-application method of insecticide application to waterside fringing vegetation for the eradication of riverine *Glossina palpalis*.

This technique was evolved in the course of field trials started in the Sukulu-Tororo area of Bukedi district in the latter half of 1955. In the first phase three treatments of 6% (wt./vol.) DDT were applied by hand-operated pre-pressurised knapsack sprayers, at intervals of 3 weeks. In the third phase two applications of 2.1% (wt./vol.) dieldrin, at an interval of 4 weeks, were used, employing the same sprayers. In the last stages of the fourth and final phase a single application of 5% dieldrin was applied by a dinghy-borne power-operated spraying machine.

Phase I reduced all catches to nil within 6 months of the start of spraying, but in Phase II (same treatment) more than 10 months were required to achieve this result. This is attributed to the abnormally heavy rains of late 1955 and March-June 1956. It did not take more than 3 months to achieve eradication in any part of the areas treated in the latter Phases III and IV in June-December 1956.

(xxiii) MISCELLANEOUS ITEMS ON PEST CONTROL FROM THE COMMONWEALTH (ABSTRACTS FROM ANNUAL REPORTS)

Western Australia

Aerial Spraying of Grasshoppers: Aerial spraying trials were carried out during the late summer and early spring in the Southern Cross district to test out the relative efficiency of water and distillate spray mixtures of dieldrin for control of the little plague grasshopper. All treatments caused heavy mortality of grass-hoppers in the treated areas, but there was some evidence to suggest that water mixtures applied during hot weather were less effective than distillate sprays. These trials indicated that early treatments gave best control.

Pasture Pests: A DDT-malathion mixture has been substituted for the previously used DDT-parathion formulation. Malathion has been shown to be very effective against the Lucerne flea and is much less toxic to higher animals than parathion. Various rates of DDT and gamma-BHC, much higher than those recommended for Cockchafer beetle control in the Eastern States, were applied to affected pastures, but no effective control was obtained.

Orchard Pest: Preliminary observations indicate that BHC and dieldrin may be effectively used for the control of Fuller's rose weevil on apple and stone fruit trees.

Malaya

Rice Stem Borers: In one experiment on control of rice stem borers, spraying with DDT at intervals of two weeks resulted in a yield increase of nearly 80% and increases of 30 to 70% were common. There is now a reasonable expectation of considerably reducing stem borer damage by spraying a month before flowering with insecticides less toxic to fish, such as DDT or dieldrin.

South Africa

Control of Grey Mite (Calacarus sp.) on Citrus: A preliminary orchard experiment was carried out to determine the effectiveness of the following control remedies: micro-sulphur (dosages 1 lb. per 100 gallons of water and 2 lb.

per 100 gallons of water), lime-sulphur(dosages 1 2/3 gallons and $\frac{5}{8}$ gallon per 100 gallons of water), and $1\frac{1}{2}$ lbs. chlorobenzilate in water. Satisfactory control was obtained with lime-sulphur, chlorobenzilate and micro-sulphur, in that order of effectiveness. Both lime-sulphur and chlorobenzilate appear to have a longer after-effect than micro-sulphur. It is doubtful whether one spring application, even of lime-sulphur, will satisfactorily control the particular mite during the whole season.

Pineapple Insects: A beetle larva (presumably a species of Macrophyllum) which causes a great deal of damage to the roots of pineapple plants, was found in a pineapple field at Bathurst. A fumigation experiment with ethylene dibromide at 2,4 and 6 ccs. per square foot in the row was carried out to control the larvae. All these treatments were effective.

Pumpkin Flies: Bait experiments were carried out with dieldrin 25 per cent wettable powder, malathion 5 per cent powder and a parathion 20 per cent emulsion. Treatment with dieldrin bait resulted in 8 per cent more marketable pumpkins than malathion treatment and 16 per cent more than the control.

Covered Soil Poisoning Tests for Termite Control: This experiment was started $6\frac{1}{2}$ years ago and it has been established that dosages of 4 to 16 gallons of copper sulphate per 100 sq. ft. were complete failures. Five per cent copper naphthenate in crude oil, dosages 8, 12 and 16 gallons and pentachlorophenol in crude oil, dosages 8, 12 and 16 gallons were all successful; 5 per cent sodium pentachlorophenate (12-16 gallons) was 100 per cent successful.

This experiment has been planned to extend over 25 years and it is hoped that treatments will be discovered which will give life protection to dwellings.

Termites: With Trinervitermes havilandi as pest insect it could be determined that certain insecticides have toxic qualities as fumigants and contacts. Compounds 1,836 and 2,046, Pestox 4 and Systox have strong fumigant action. Pestox 14 and compound 1,836 show persistent residual fumigant qualities. Compounds 1,836 and 2,046 were the most effective as contact poisons. Systox,Metasystox and Isoland have also shown strong contact properties.

As a result of experiments carried out to determine the toxicity of systemic insecticides by contact and fumigation action after they have been absorbed by the plant tissues, it was established that compounds 1,836 and 2,046 show strong contact and fumigant toxicity after absorption. In this respect Systox was less effective. It was further established that chlorobenzilate, F.W.293, Chloroparacide and C.P. 36/55 show poor contact reactions against Trinervitermes havilandi. Diazinon is an excellent contact insecticide.

Mites: It was determined by means of laboratory tests that diazinon controls adult Tetranychus bimaculatus mites very effectively. Chlorobenzilate, Chloroparacide, C.P. 36/55, F.W. 293 and Aramite were relatively less effective or ineffective. As ovicides, F.W. 293, C.P. 36/55, chlorobenzilate, Chloroparacide and diazinon have furnished promising results. Aramite was less effective.

Experiments conducted with certain systemic insecticides with a view to studying the effect of their contact or fumigation on red mite (Tetranychus bimaculatus) have shown that Pestox 101, Systox and a compound 2,046 were very effective as contact insecticides. Compound 1,836, Pestox 14 and Systox have furnished promising results as fumigants.

Earthworms: Experiments were carried out to determine whether systemic insecticides have a detrimental effect on the earthworm when they are applied to the soil. Results prove that Systox, compound 1,836 and compound 2,046, when used at the prescribed rates and concentrations are completely safe for use in soil where earthworms are present.

Wattle Bagworm: Surveys of bagworm in plantations sprayed during the past three years are being continued. Epidemics of the fungus Isaria psychidae have exterminated a large part of bagworm infestation in sprayed as well as in unsprayed plantations, but the control obtained is not sufficient to ensure freedom from damage on some of the younger plantations.

Aerial spraying of wattle plantations with (a) 1 fluid ounce of endrin in three gallons of crude oil per acre gave 84.1 per cent control and (b) 2 fluid ounces of endrin in three gallons of crude oil gave 92.3 per cent control, whereas the endrin emulsion, 2 fluid ounces in three gallons of water gave only 65.7 per cent control. Two ounces of endrin and half a pint of Alboleum in three gallons of water per acre gave 95.3 per cent control. All results were assessed after 16 days. Endrin emulsion with Alboleum added, therefore, appear to be very promising and they have the advantage of eliminating the transport of crude oil.

Pesticides - Residue Analysis: Samples of mealiemeal prepared from insecticide-treated mealies were analysed for BHC content for the Mealie Industry Control Board. Attempts to determine quantities of DDT of the order of a few parts per million in the same samples by the potentiometric titration of the total chlorides were unsuccessful. Results obtained by using the Stiff-Castillo colorimetric method were misleading due to the instability of the Xanthydrol reagent. This method is not considered suitable for routine analysis and research is being continued in an effort to find a suitable method for determining DDT.

Simultaneously with the large scale experiments on the extermination of finches (Quelea-Quelea) by air-spraying being conducted by the Division of Entomology, numerous samples of sprayed material were taken and analysed for parathion in order to establish how the activity of the poison residues on vegetation diminished with time of exposure to the atmosphere. This investigation is being continued.

Various solutions of dyestuffs have been tested as means of colouring birds by air spraying, to facilitate observations on the habits of finches.

(xxiv) FRUIT TREE SPRAYING

(Ministry of Agriculture, Fisheries and Food,
Bulletin No. 5.)

First published in 1927 this bulletin, now in its 5th edition, has been entirely re-written and brought up-to-date. The text has been prepared by Mr. B. M. Hodgkin in collaboration with the Fruit Group of the N.A.A.S. under the chairmanship of Professor T. Wallace.

The purpose of this bulletin, "to assist growers to select the equipment most suited to their needs or to obtain the best service from the machinery that they have", is adequately fulfilled. The subject is introduced with notes on conventional spraying methods (hydraulic pressure), new techniques (air-flow), on dusting and on the right time of application.

Chapter I on "Planning" contains matters apposite to the efficient use of pesticides including programming, personnel, safety precautions, availability of water, keeping of records and preparation and maintenance of machinery.

Machinery (Chapter II) and Equipment (Chapter III) absorb the major part of the text. Descriptions of the basic principles are given i.e. tank, pump and nozzles; also accounts of hose and connections, lances and taps, spray guns, filters, relief valves, pressure regulators, pressure gauges, tank-filling pumps and agitators.

Machines are grouped according to output and suitability for different conditions. Following a general passage on choice of machinery, various types are listed including lance sprayers (hand pumps, small and tractor drawn power pumps and underground mains), automatic fixed bar sprayers, air-flow systems and dusting machines.

The efficient use of machines is discussed under 'Operations' (Chapter IV). The avoidance of drift is noted as a general problem to be solved. A method of spraying a 25-tree square from a central standpipe is described with diagram and there is included a section on maintenance also a fault-finding table.

Calculations for automatic spraying and a list of advisory leaflets on diseases and pests are to be found as appendices. The text is well illustrated with 16 photographs and several diagrams.

CHEMICAL COMPOUNDS USED IN AGRICULTURE, ETC. IN GREAT BRITAIN.

Recent additions to the Ministry of Agriculture, Fisheries and Food dossier covering agricultural and horticultural practice in Great Britain. (See News Item (vii), PANS (A), 1957, 3, (2), 46).

Demeton
Diazinon
Dimefox

Dipterex
Fluoracetamide

Griseofulvin
Metasystox
Simazin

(xxv) CROP PROTECTION PRODUCTS APPROVAL SCHEME, APPROVED LIST: 1957

Following the general pattern introduced last year the present (expanded) booklet consists of an index and four sections:

1. List of approved products arranged alphabetically under common or chemical names and subdivided by formulation. (Informative notes relating to safety and application are presented with each group).
2. Tabulation of crops and recommended weedkillers.
3. List of weeds and their susceptibilities to various weedkillers.
4. Manufacturers' names and addresses.

The booklet is well indexed: common and Latin names of plants, pests and chemicals are given. A reference key denotes whether full or partial control can be anticipated for a recommended treatment and draws the reader's attention to available M.A.F.F. leaflets and bulletins.

Copies are obtainable from the Ministry of Agriculture, Fisheries and Food (Publications), Soho Square, London, W.1.

(xxvi) CONTROL OF FLIES IN FISHMONGERS' SHOPS

Department of Scientific and Industrial Research. Advisory Note No. 11 London, 1957.

Control measures consist of spraying insecticide, inside and out, coupled with hygiene (e.g. quick disposal of offal, use of coverings and general cleanliness). Blow-fly species, Calliphora, Lucilla and Phormia, along with houseflies, are troublesome.

Insecticide recommendations are:

(1) To apply daily a proprietary fly spray, containing pyrethrum, with DDT or lindane, from an efficient hand sprayer, or with an aerosol, or vapour, dispenser, after the premises are closed and foodstuffs have been stored away. After treating, food bearing surfaces should be well scoured and wooden bench tops scrubbed with hypochlorite (0.0001%).

(2) To treat the out-premises by spraying liberally, each week, outside of bins and lids (both sides) with a dispersible powder or emulsifiable concentrate of DDT at a dosage equivalent to 1 oz DDT per pint water, using bucket type pump. Also, to spray surrounds, fortnightly, with DDT at $\frac{1}{2}$ lb. per gallon per 1000 sq. ft.

Fish boxes are treated by rinsing with detergent followed by a strong hypochlorite wash.

(xxvii) RECOMMENDED COMMON NAMES FOR PESTICIDES

B.S. 1831:1957 (August 1957)

This British Standard has been prepared under the supervision of the Pest Control Products Industry Standards Committee consisting of representatives from Industry, Scientific Societies and Government Organisations. It is a revision of B.S. 1831 Pts. 1 and 2 published in 1952/53.

Recommended common names, arranged alphabetically and correlated with chemical names and formulae, are essentially of short, distinctive character. They have been formed, when possible, from a combination of syllables from the scientific chemical name. The first chemical name is based on principles recommended by the Chemical Society. Synonyms are noted.

(xxviii) WORLD HEALTH ORGANIZATION, EXPERT COMMITTEE ON INSECTICIDES SEVENTH REPORT

W.H.O. Technical Report Series No. 125, Geneva 1957.

This report was originally issued in mimeographed form as a document WHO/Insecticides/53, 23 July 1956. Contents are as follows:-

1. Resistance of insects to insecticides:

   International collaborative programme of research on the resistance of insects to insecticides.

   Present status of resistance among insect vectors of disease and methods for detecting resistance.

Biological aspects of resistance.

Possibility of alternative control methods where resistance has developed.

2. Disinsectization of aircraft.

Annex 1. Aerosol formulations which have been found effective in practice.

Annex 2. Test procedures for aerosols and aerosol dispensers.

(xix) INSECT CONTROL IN SUTTON COLDFIELD PARK

Zaldecide formulations (manufactured by Newton, Chambers & Co. Ltd., Thorncliffe Nr. Sheffield) were applied by the Sutton Coldfield Health Department against flies, midges, mosquitoes and other biting insects in Sutton Park, site of the recent Scouts' World Jamboree.

The first, a water-dispersible concentrate containing 6% dieldrin, was diluted to 1 in 3 and applied through the Swingfog as a mist. This was designed to be projected into the wooded areas to deal with flying adult insects. Controlled trials with this instrument and product gave an estimated kill of 90% in the treated areas.

The second was a 2% dieldrin dust in a siliceous base. This was projected from a pressurised blower. The dust was designed to be distributed over the marshy and boggy areas of the park surrounding the lakes as a long term insecticide to destroy adult midges resting upon the foliage and midge larvae in the wet moss and soil.

(xxx) AERIAL SPRAYING AGAINST PHASMIDA IN NEW SOUTH WALES

Abstracted from the de Havilland Gazette No. 100. 1957.

In the Bago State Forest in New South Wales Phasmida have been causing serious damage every second year since 1952. An aerial spraying trial has been carried out, using a D. H. Beaver aircraft, applying dieldrin and BHC, 1 oz per gallon in dieseline at 1.3 gallons per acre. Flying at 100 m.p.h. 100' above tree top, the effective swathe width was 100' allowing a 20% overlap. The runs were of $1\frac{1}{2}$ miles, 20 gallons of spray being delivered in 55 seconds.

The Beaver carried a 200 gallon tank, though the full capacity was not used in this experiment, and was equipped with a spray boom carrying 17 nozzles under each wing.

Results of the trial which have been collected so far have adequately satisfied the Forestry Commission. With reference to the performance of the aircraft the Chief Forest Entomologist, Phillip Hadlington, states: - "The Beaver was able to deliver its load over the area with considerable accuracy, and it seem evident that this aircraft is quite satisfactory for this type of work over forest country."

(xxxi) PROTECTION AGAINST AMBROSIA BEETLE

The Standardised Disinfectants Co. Ltd. of 23, Sloane Street, London, S.W.1, have produced a leaflet describing Hexastan LP, a formulation specially prepared for protecting logs from Ambrosia beetle (pinhole borer) attack. The concentrate is diluted with water for spraying at $\frac{1}{4}$ - $\frac{1}{2}$ gallon per 100 square feet of surface; after drying, a water resistant insecticidal film is formed. Logs do not have to be debarked before application.

Protection for 10-12 weeks is claimed, on the basis of the results of experiments carried out by the West African Timber Borer Research Unit, and the Forest Departments of British Honduras and British North Borneo.

S.D.C. are also producing Protostan Log Grease which has been found (by a West African Timber Company) to give good protection to floating logs against water line attack by Ambrosia beetle. No leaflet is yet available on this product, but further information may be obtained from the Company.

(xxxii) PEST AND DISEASE CONTROL ON COFFEE

The Shell Petroleum Company Ltd.

The Shell Petroleum Company Ltd. of St. Helen's Court, Great St. Helen's, London, E.C.3, have announced the introduction of a new series of booklets on the use of Shell chemicals in the control of pests and diseases of economically important crops.

The first of these: "Pest and Disease Control on Coffee" has recently been published. It contains 36 pages, with numerous illustrations, and has sections on insect pests, nematodes, fungus diseases, weedkillers, and notes on the handling of Shell chemicals. Recommendations are made, with dosage rates and application time, for the treatment of a comprehensive range of coffee pests and diseases.

(xxxiii) GEIGY MITICIDE (AKAR 338)

A leaflet, describing AKAR 338 (25% emulsifiable concentrate based on chlorobenzilate) is available from the manufacturers (Geigy, Rhodes, Middleton, Manchester, England).

Intended for the control of mite, chiefly red spider, on fruit, flower and vegetable crops, it is stated to be effective against egg (summer), nymphs and adult stages of that pest, though harmless to its predators. The solution for spraying is prepared by diluting 1 part of concentrate with 1000 parts water.

Tests made in the U.K. and overseas indicate that the spray is without phytotoxic effect on plant foliage or crops. Trials on cucumbers and stone fruits are in progress. It is compatible with most spray materials in common usage except lime sulphur and Bordeaux mixture; in doubtful cases preliminary checks are advised. It is claimed to be perfectly safe to use without special precautions.

(xxxiv) 'CERESAN' WB

Bayer Agriculture Ltd. of Thornycroft House, Smith Square, London, S.W.1, announce a new dual-purpose seed dressing 'Ceresan' WB, for use against wheat bulb fly (Leptohylemyia coarctata). This contains 40% gamma BHC together with organo-mercury fungicides. An application rate of 2 ozs per bushel of wheat is recommended and it should be used only on good quality grain with a moisture content not exceeding 16%. Preferably drilling should take place within one month of treatment. It is expected that best results will follow its use on crops sown after mid-November.

Bayer, in common with most other workers have concluded that neither seed dressings nor insecticidal dusts are completely effective control measures. The degree of control obtained varies with the stage of growth of the crop at which attack takes place and these factors vary according to when the crop was sown and the time at which the bulb fly eggs hatch. In view of the conditions this year, which appear to favour wheat bulb fly, this formulation is announced in order to make available the best possible means of control.

Additional information is available from Bayer Agriculture Ltd.

(xxxv) THE PROTECTION OF GRAIN, FLOUR AND OTHER FOODSTUFFS

A useful guide to the utilisation of "Gammexane" formulations (containing the insecticide gamma BHC) for help in controlling pests of stored products is available from Plant Protection Ltd. (Fernhurst, Nr. Haslemere, Surrey).

In a preface to the booklet comment is made on the vast amount of food material ravaged by insects. Total losses, largely avoidable, are reckoned to be equivalent to the annual food requirements of 100 million people. Sound storage practice involving hygiene, ventilation, temperature, humidity, stacking methods and rotation of stocks, coupled with the use of insecticide, are advocated.

Four formulations (tabulated below) produced from lindane quality BHC (99% gamma BHC) are specified for stored product use. It is indicated that the insecticide is without harmful effect on germination even after long storage. Relevant details concerning its safe application are quoted from the code of practice prepared by the Colonial Office.

Control measures are described for the treatment of infested premises such as warehouses, stores and ships' holds, of silos, bins and garners and of maltings and breweries. Procedures are set out for treatment, in bulk or bag, of clean and infested grain and of seed; also for flour and other cereal products. An outline is given of the treatment of peas, beans, coffee, oilseeds, cocoa and cheese.

Good line-block illustrations of several pests accompany the text which includes descriptions of their appearance, habits, etc. There is a final section relating to suitable dusting and spraying equipment.

Standard Dosage and Dilution Rates

"Gammexane" Product	Recommendations
Insect Powder (0.5% BHC)	1-2 oz. per 3 sq. yds.
50% BHC Dispersible Powder	$\frac{3}{4}$ oz. per gallon of water to treat 1000 sq. ft.
20% BHC Emulsion Concentrate	Dilute with 39 parts of water or odourless kerosene and apply at $\frac{1}{2}$ - 1 gallon per 1000 sq. ft.
Smoke Generators	Apply 1 No. 25 generator per 10,000 cu. ft. Apply 1 No. 22 generator per 1,000 cu. ft.

(xxxvi) FIDO - MOTORISED KNAPSACK SPRAYER/DUSTER

Bertani R. & E. Factories of Via L. da Vinci 39/41, Abbiategrasso (Milano), Italy, have introduced the "Fido" motorised knapsack sprayer/duster which they describe as "an air stirring atomiser".

The machine is powered by a 58 c.c. (1.75 h.p.) two-stroke engine working on a petrol mixture. Fuel consumption is 0.6 litres/hour. Engine speed is variable, as is the discharge rate for both liquids and powders. Droplet size is about 30 microns. Liquids can be discharged to a height of 8 metres, and dusts to 10 metres, horizontal range is 10 metres for liquids and 12 metres for dusts.

	Normal Tank	Large Tank
Empty weight	15 kg	15.5 kg
Fuel capacity	2 litres	2.5 litres
Capacity liquids	10 "	20. "
Capacity powders (sulphur base)	5 kg.	10 kg.
Additional weight for duster	0.7 kg.	0.7 kg.

(xxxvii) CONTROL OF THE HAWTHORN SPIDER MITE TETRANYCHUS VIENNENSIS ZACHER

G. F. W. MÜLLER. Extract from Bayer Plant Protection Department, Hofchen-Briefe, 1957, No. 1. (English Edition).

Following an application of commercial winter sprays (DNC, yellow oil, carbolineum oil), up to 20% of the winter females survive. Consequently, a winter treatment is not fully effective, and therefore not completely satisfactory.

A summer spray application with phosphoric esters ("E 605" conc., "Systox") ensures absolute success. The effect of "Solbar" against *T.viennensis* is unsatisfactory.

(xxxviii) A SURVEY AND TRIAL OF THE USE OF INSECTICIDAL FOG IN PUBLIC HEALTH WORK.

R. D. HUGHES. A Monograph on Fogging Technique issued by Shell Petroleum Company. Public Health Bulletin ADB:474/Ta 17.

The Swingfog Generator Model SN-6, incorporating a changeable spraying head, which is capable of producing droplets in 3 diameter ranges is described.

Dry fog	10-30 μ (mean 15 μ):
Wet fog	20-70 μ (" 40 μ):
Fine spray	50-100 μ and above (mean 85 μ).)

A flow control system for the insecticide is fitted allowing a 2-3 times variation in cloud density.

TABLE I - PERFORMANCE DATA SN-6

Flow control system		Rate of application gallons/hour		Rate of dispersion minutes/gallon	
Control sets	Screw valve	Diesel oil	Water	Diesel oil	Water
0.8 mm	2¾ turns	2.54 gall.	-	23.6 min.	-
0.9 mm		2.92 "	-	20.5 "	-
1.0 mm		3.39 "	-	17.7 "	-
1.1 mm	3 turns	4.00 "	-	15.0 "	-
1.2 mm	3¼ "	4.90 "	4.25 galls.	12.3 "	14.1 min.
1.4 mm	3½ "	5.62 "	5.25 "	9.6 "	11.4 "

The machine is of simple construction and reliable provided the manufacturer's servicing instructions are carried out. With fairly low flash-point solvents however there is a danger of ignition if the unit stops during operation. In this case the flow control tap should be turned off immediately and the machine held with the nozzle pointing down.

The efficiency of fogging is dependent on the nature of the terrain, (greatest fog concentrations being produced over flat, vegetation-free country), and the weather conditions. "Inversion conditions" - i.e. when the air near the ground is cooler than that above, for example at night and near dusk and dawn - are very suitable for fogging since there is a smooth air flow and little turbulence to break up the fog cloud. Fogging should not be carried out if the air 20 ft. above the ground is more than 5°F warmer than that at a height of 6 ft.

For fogs (wet or dry) the insecticide must be carried in an oily solvent. A high quality emulsion (no tank agitation on the machine) can be used for fine sprays. With normal concentrations of insecticides volatile carriers are best with wet fogs, and non-volatile for dry. For general outdoor work kerosine solvents have been found satisfactory.

The Swingfog is also suitable for fumigation of enclosed spaces, though with some explosive risk. Precautions that should be taken are:

(i) Extinguish all naked flames,
(ii) Turn off electricity supply,
(iii) Use less than the equivalent of 1 gal. liquid for 50,000 cubic foot of air space,
(iv) Use a non-inflammable formulation if possible,
(v) If possible project the fog into the space from a machine outside.

For recurrent insect problems fogging should normally be adopted as an occasional supplement to a basic control programme. Fogging alone is uneconomical, but it can often be used as an emergency treatment for a new insect problem.

The toxicity hazards of the method should be kept in mind. The very small droplets in the fog cloud are of a size which readily reach the absorption areas of the lung.

(xxxix) CHANGES IN THE REACTION CHAINS IN THE INSECT ORGANISM CAUSED BY DIETHYL-p-NITROPHENYL THIOPHOSPHATE. (AUTHOR'S SUMMARY)

Fr. JOCHUM. Bayer Plant Protection Department. Höfchen-Briefe, 1956, No. 6. (English edition).

Following the application of "Folidol-E 605" as a contact poison, the glands of the digestive tract in insects are stimulated to form secretion in a most vigorous and persistent manner. The superabundant quantities of secretion formed may be discharged through the mouth opening. The nature and quantity of the discharged secretion depend upon the quantity of blood present in the different insect species, also upon the nature and function of the glands, and upon the construction features of the digestive tract.

Weighings of secretion discharged during the process of poisoning indicate the extent and intensity of fluid displacement in the insect organism. The unnaturally high loss of fluid comes to an end in the initial stage of the excitation phase. The excretion of solid and fluid substances during the remainder of the poisoning process is no greater than in normal insects.

Histological studies show that the activity of the glands increases even before any symptoms of poisoning become apparent from the behaviour of the insect.

In addition to the secretion of fluid, there is also an abnormal increase in the eliminatiin of gases from poisoned insects. The intensity of oxygen uptake is already above normal before commencement of the excitation phase. The O_2 rate increases linearly from before the start of the excitation phase until the poisoned insect is more or less incapable of reacting.

From the commencement and the continuation of the intensified process of metabolism, it is obvious that the increased uptake of oxygen cannot be induced by motor hyperactivity, nor is it additionally increased by excessive muscular activity during the excitation phase. It is concluded that the intensification of metabolsim is caused by a lack of fluid in the body-activity, and that in the first place it serves to produce water of metabolism. The hyperexcitability and the motor hyperactivity following the intensification of metabolism, are automatic secondary symptoms resulting from the super-normal release of heat energy and the formation of superabundant products of metabolsim.

As a result of the heavy secretion of fluid arising out of super-normal glandular activity, the water content of the blood is reduced and the composition of the dry substance changed.

The constant limitation of the O_2 rate at a maximum equalling on the average four to five times the normal value, is explained as the outcome of the pronounced change in the quantity and composition of the blood plasma and the resultant hindrance of the exchange and translocation of products of metabolism, in the sense of Wigglesworth's theory of respiration.

The nerve tissue of the Dendrolimus pini L. caterpillar, in which the process of poisoning continues over a relatively long period, is taken as an example to show that the large extraction of fluid from the haemolymph can also lead to a loss of water in other organs.

The hydrogen ion concentration of the haemolymph decreases and that of the mid-intestinal contents increases when the blood undergoes a change.

The peroxidase, dehydrase and catalase actions of the blood and the muscular and nerve tissue were studied during the process of poisoning. The manner in which the enzyme actions change, may be interpreted to a certain extent as being due to an increasing enzyme concentration.

The histological examination of the ganglion chain did not reveal any specific changes after poisoning with "Folidol-E 605". The first changes appear in the form of cell, nucleus and nucleolus hypertrophia, at the earliest in the late stage of excitation.

The atrophy of the haemolymph in the region of the organic structure resulting from the displacement of the body-cavity fluid into the digestive tract, is to be regarded as the cause of death to insects following poisoning with "Folidol-E 605".

In the discussion, it may be pointed out that application of other lipophile contact poisons causes the same course of disease as "Folidol-E 605".

With respect to the site of attack, it is assumed that all organic lipophile contact insecticides act in the same manner - even though at varying strength - because they cause changes in the cell boundary layers due to, and corresponding to their affinity to the cell lipides.

(xl) RECENT PROMOTIONS, TRANSFERS AND APPOINTMENTS

The following list compiled from the information supplied by the Colonial Office, includes only the officers whose duties will be concerned with entomology, pest control and related fields.

July 1957

Johnson, C. E. Chief Agricultural Officer, Northern Rhodesia	Assistant Director pf Agriculture, Northern Rhodesia.
Webdale, J. V. Agricultural Officer, Tanganyika.	Agricultural Officer, Zanzibar.
Lamb, A. F. A. Conservator of Forests, Trinidad.	Chief Conservator of Forests, Sierra Leone.
Thorne, A. L. C., M.R.C.V.S. Senior Veterinary Research Officer, Federation of Nigeria.	Deputy Director of Veterinary Research, Federation of Nigeria.
Armstrong, J.	Agricultural Officer, Northern Rhodesia. (first appointment)
Barnes, T. R.	Agricultural Officer, Western Region, Nigeria. (first appointment)
Boyd, W. J. R.	Agricultural Officer, Northern Rhodesia. (first appointment)
Gunn, A. J. M.	Agricultural Officer, Tanganyika. (first appointment)
Jones, D. J. H.	Agricultural Chemist, Northern Rhodesia. (first appointment)
Keir, W.	Agricultural Officer, Kenya. (first appointment)
Simons, J. H.	Plant Protection Officer, (Plant Pathologist), Western Region, Nigeria. (first appointment)

August 1957

Dale, S. S. Livestock Officer, British Honduras.	Chief Agricultural Assistnat, Jamaica.

Rice, T. Hughes- Provincial Agricultural Officer, Kenya.	Assistant Director of Agriculture (Field Services), Kenya.
Clarke, E. C. Assistant Conservator of Forests Class II, Cyprus.	Assistant Conservator of Forests, Class I, Cyprus.
Moore, D. Deputy Conservator of Forests, Trinidad.	Conservator of Forests, Trinidad
Mouskos, J. C. Administrative Officer Class II, Cyprus.	Assistant Conservator of Forests Class I, Cyprus.
Scott, W. N., M.R.C.V.S. Assistant Director of Veterinary Services (Field), Uganda.	Deputy Director, E.A.T.T.R.O., East Africa High Commission.
Clarke, E. K.	Agricultural Officer, Nyasaland. (first appointment)
Hill, D. M.	Agricultural Officer, Nyasaland. (first appointment)
Law, J. P.	Agricultural Officer, Sierra Leone. (first appointment)
Le Poidevin, N.	Agricultural Officer, Gambia. (first appointment)
McDonald, D.	Plant Pathologist, Northern Region, Nigeria. (first appointment)
Martini, C. K. H.	Plant Pathologist, West African Cacao Research Institute, Western Region, Nigeria. (first appointment)
Moffatt, T. G.	Agricultural Officer, Northern Region, Nigeria. (first appointment)
Orpin, R.	Agricultural Officer, Nyasaland. (first appointment)
Thomas, D. J. H.	Agricultural Officer, Western Region, Nigeria. (first appointment)

Burgess, J. M. S.	Assistant Conservator of Forests, Nyasaland. (first appointment)
Gregor, E. W.	Assistant Conservator of Forests, Somaliland Protectorate. (first appointment)
Webb, D. B.	Assistant Conservator of Forests, British Honduras. (first appointment)

September 1957

Gamble, G. Agricultural Officer, Kenya	Provincial Agricultural Officer, Kenya.
Harrison, W. J. Assistant Conservator of Forests, Western Nigeria.	Senior Assistant Conservator of Forests, Western Nigeria,
Guy, H. C. W. Dip. Agric. Livestock Improvement Officer, Kenya.	Principal Livestock Improvement Officer, Kenya.
Gollinger, D. F.	Agricultural Officer, British Guiana. (first appointment)
Robertson, I. A. D.	Entomologist, Tanganyika. (first appointment)
Thompson, P. A.	Agricultural Officer, Fiji. (first appointment)
Wallace, C. R.	Entomologist, St. Helena. (first appointment)
Crown, M.	Assistant Conservator of Forests, Northern Rhodesia. (first appointment)
Reid, P. R.	Assistant Conservator of Forests, Federation of Nigeria. (first appointment)
Branagan, D., M.R.C.V.S.	Veterinary Officer, Tanganyika. (first appointment)
Forest, E., B.V.Sc., M.R.C.V.S.	Veterinary Officer, Jamaica. (first appointment)
Turnbull, A. S., M.R.C.V.S.	Veterinary Officer, Jamaica. (first appointment)

57/52 AIRCRAFT APPLICATIONS FOR ANOPHELINE CONTROL - PREVENTION OF A SEASONAL INCREASE WITH A GRANULATED FORMULATION OF DIELDRIN

D. YEO. Colonial Pesticides Research Unit, Arusha, Tanganyika, and D. BAGSTER WILSON, East African Institute of Malaria and Vector Borne Diseases, Amani, Tanganyika.

An account is given of an attempt to prevent the seasonal peak of anopheline vector breeding in an East African coastal town by the addition of aircraft applications of a granulated formulation containing dieldrin to the other methods of control.

A dosage of 1 lb. of 2% (w/w) dieldrin granules per acre was applied, and the characteristics of this material and its mode of application are described. Seven treatments were given over a period of eight weeks.

Considerable difficulties were experienced in the assessment of the trial, because of the introduction of other additional methods of control over a wider area than in the past, the inapplicability of measurements of human malaria, and a year of early heavy rain that stopped abruptly.

The anopheline larval assessment showed that the formulation was very effectively larvicidal.

In houses adjacent to the treated areas, catches of anopheline vector adults were reduced to less than one per room within six weeks after the first treatment, and were in effect nil for some months after that. Where aircraft control was added to the ground control, the catches of vectors were reduced to nil within six weeks.

It is estimated that, as compared with other areas and other years, the effectiveness of the method in reducing anopheline adult population was of the order of at least 90%.

It appears highly probable that this degree of control persisted for a further four months.

The cost of a single application was approximately £100 per square mile.

57/53 PARE-TAVETA MALARIA SCHEME. PROGRESS REPORT No. 7. JANUARY-JUNE 1957. (AUTHOR'S SUMMARY).

The effect of residual spraying has become apparent in the human indices. In adults spleen and parasite rates have fallen to about one quarter of their previous level, in older children rather less than this, and in young children much more. From the special watch on infants in South Pare, it is concluded that a very few new infections are still being acquired in the area.

Such analysis as has so far been carried out of the examination designed to reveal the effects of malaria on human health also gives some preliminary results. Haemoglobin levels have risen among the younger children and also among those over 40 years old, and there also appears to be some decrease in the frequency of occurrence of oral temperatures raised above 99°F.

Anopheline house infestation with A. gambiae has remained at a low level, if anything rather lower than during the previous year, and the reduction is about 96 per cent of the pre-spraying figures. Two positive gland infections have been found in over 2500 gambiae dissected. A. funestus is still absent.

There has been no evident change in the feeding habits of gambiae, either in houses or out of doors.

In treated experimental huts the observed mortality is 69 per cent in Anopheles found, and observations on the effect of dieldrin on gambiae applied to impregnated walls, or tested by the Busvine technique, show no loss of susceptibility to dieldrin in the area.

The total cost of spraying fell from shillings 6.80 per house in the second spraying cycle to sh. 5.38 in the third.

57/54 THE SUSCEPTIBILITY OF ANOPHELES GAMBIAE GILES FROM MOMBASA AND DISTRICT TO DDT, GAMMA BHC AND DIELDRIN.

J. ARMSTRONG. Colonial Pesticides Research Unit, Arusha, Tanganyika. Misc. Rep. No. 181.

A survey to assess the susceptibility of A. gambiae to insecticides was carried out in the Mombasa district from 5/4/57 to 8/5/57. Tests to determine whether there was any insecticide resistance in the area were included.

For the experiments adult mosquitoes were bred in the laboratory from larvae breeding locally near Mto Panga. The adults were exposed, in lots of 10 per tube, for one hour, to filter papers impregnated with risella oil solutions of the insecticides DDT, gamma BHC and dieldrin. After a 24 hour holding period the percentage mortality was determined. Controls were exposed to non-insecticidal filter papers, and a correction applied to the test results if necessary.

In the tables are shown the percentage mortalities with the number of insects tested in brackets.

TABLE 1

Susceptibility of Adult Female A.gambiae to DDT.

Control	0.25	0.5	0.7	1.0	2.0
0(7)	23(30)	36(47)	29(38)	47(19)	92(92)

TABLE 2

Susceptibility of Adult Female A.gambiae to gamma BHC

Control	0.0025	0.005	0.01
15(40)	29(78)	53(49)	98(63)
0	15	42	91

TABLE 3

Susceptibility of Adult Female A.gambiae to Dieldrin

Control	0.025	0.05	0.07	0.1	0.25
0(23)	38(50)	96.8(64)	100(59)	100(8)	100(102)

For DDT the MLC (Median Lethal Concentration - the concentration at which 50% of the mosquitoes were killed) is 0.75% comparable with 0.75% for the colony at Arusha and 0.80% for Zanzibar.

For gamma BHC the MLC is: Mombasa 0.005%; Arusha colony 0.009%; Zanzibar 0.004%. The Mombasa and Zanzibar mosquitoes have about the same susceptibility and are two to three times as susceptible as those from the Arusha colony.

Dieldrin gave Mombasa MLC 0.027%; Arusha colony MLC 0.114%; Zanzibar MLC 0.044%. The A. gambiae from Mombasa is about twice as susceptible to dieldrin as the Zanzibar type and about four times as susceptible as the Arusha colony type.

57/55 THE TOXICITY OF THREE ORGANIC PHOSPHORUS INSECTICIDES TO HOUSEFLIES AND MOSQUITOES.

A.B. HADAWAY and F. BARLOW. Colonial Pesticides Research Unit, Porton. Report No. 142.

The insecticidal toxicity of some organic phosphorus compounds of low mammalian toxicity has been determined. Test insects were Musca domestica L., Aedes aegypti L., Culex pipiens molestus Forsk, Anopheles stephensi List., Anopheles quadrimaculatus Say., Anopheles gambiae Giles.

The insecticides, used in kerosene solution, were Chlorthion, diazinon, and malathion. They were applied direct to the dorsal surface of the thorax of each insect by micro-burette, Results are tabulated below, with comparative figures for three chlorinated hydrocarbon insecticides.

LD50 (μg per Insect)

	Chlorthion	Diazinon	Malathion	DDT	Gamma BHC	Dieldrin
Musca domestica	c. 0.33	0.077	0.77	0.320	0,080	0.022
Aedes aegypti	0.0039	0.0142	0.0061	0.018	0.0038	0.0047
Culex pipiens molestus	0.0059	0.0248	0.0129	0.0085	-	-
Anopheles stephensi	0.0081	0.0040	0.0056	0.018	0.0019	0.0019
Anopheles gambiae	0.0019	0.0033	0.0028	-	-	0.0010

Anopheles quadrimaculatus: Diazinon (0.009 μg/insect) Mortality 63% (38 females used)
Chlorthion (0.009 μg/insect) " 0% (38 females used)

57/56 A BIOASSAY TECHNIQUE FOR ANOPHELES LARVAE

R. ELLIOTT. Federal Malaria Service, Yaba-Lagos, Nigeria.

This technique attempts to overcome the disadvantages of earlier bioassay techniques in which either highly concentrated insecticide solutions, or long time exposures are required.

It appears to be essential that containers for both exposure to the insecticide and subsequent recovery should be shallow, but the exact shape, or material, does not seem critical. Fourth instar larvae are used. The test dilutions of the toxicants are prepared by adding quantities not exceeding 1 ml. of ethanol solution to 1 litre of water. This minimises the effect due to the presence of the solvent. Larvae are handled by a "lifter" made of nylon net stretched over a circular frame 32 mm. in diameter. A minimum batch of 20 larvae is aimed at.

An exposure period of 1 hour gives satisfactory results and avoids mortality in the controls due to starvation. The recovery period, spent in clear water, is standardised at 5 hours, and dried yeast is added as food. At the end of the recovery period all larvae are forced to the bottom of the container, and those returning to the surface skimmed off with the lifter. The disturbance caused by this, and by the subsequent counting of the dead individuals lying at the bottom is sufficient stimulus to activity for those still capable of normal swimming to demonstrate their ability.

The semi-micro scale of the method, and the short exposure and recovery times, make it a particularly suitable one for field surveys. A cardboard carton 13 x 12 x 10 inches contains all the apparatus required, including the collecting kit and holding bowls. The short period between commencement of exposure and estimation of mortality means that the variation in temperature during each test is much less than if each trial ran overnight. The temperature during exposure and recovery is in the case of some toxicants an important variable, and where it cannot be controlled, the range should be observed.

57/57 THE EFFECT OF ACETONE CONCENTRATION AND LARVAL DENSITY ON THE MORTALITY OF AEDES AEGYPTI LARVAE EXPOSED TO DDT AND DIELDRIN.

A. H. PARKER. Colonial Pesticides Research Unit, Porton.
Report No. 143. June 1957.

Experiments are described which indicate that the presence of traces of acetone (0.001 to 0.1%) in water, containing DDT or dieldrin in median lethal concentration to *Aedes aegypti* larvae, is without significant effect upon the mortality rate of the immersed larvae. On the other hand, exposure tests with larvae of given age-groups to constant volumes of test media showed that under certain circumstances mortality may be much effected by larval density.

Concerning this second factor, reduction in the density of eighth-day larvae from 20 to 10, or from 10 to 5, larvae per 100 c.cm. of either DDT or dieldrin "solution" resulted in a marked rise in mortality when exposures were for 24 hours, but no significant change when they were for one hour. Increasing the density of eighth-day larvae exposed to DDT for one hour above the 20 per 100 c.cm. level did, however, result in a reduction in mortality. When 24-hour exposures were carried out on fourth-day larvae, variation of larval density within the range of 5-20 larvae per 100 c.cm. affected the mortality when the insecticide was DDT, but not when it was dieldrin.

It is concluded therefore that a standardised susceptibility test for either anopheline or culicine larvae should include in its specifications the number of larvae to be exposed to a given amount of the test medium.

57/58 STUDIES ON SOME ASPECTS OF THE EFFECT OF THE SOLVENT ON THE TOXICITY OF SOLUTIONS OF INSECTICIDE

A. B. HADAWAY and F. BARLOW. Colonial Pesticides Research Unit, Porton, Report No. 116.

This paper sets out a series of experiments designed with the object of correlating properties of various solvents, in formulation, with corresponding insecticidal toxicities. Insecticidal potency was adjudged on mortality rate among test insects *Aedes aegypti* L. and *Musca domestica* L., mainly following their exposure to films of various insecticidal solutions and, in a few cases, after topical applications. Both techniques are described. Regarding the solvent/insecticide combinations, only contact insecticides (including pp' DDT, Prolan, dieldrin, endrin and technical malathion) were employed. A check test served to eliminate insecticides with fumigant action.

Solvents chosen are relatively involatile, without physiological effect and are able to "wet" the test insects. Physical properties, including b.p., viscosity, surface tension and insecticide solubility at 25°C are noted, together with median lethal concentrations, in a number of cases.

Solvents employed in filter paper tests consisted essentially of paraffinic hydrocarbons or fractions; long-chain paraffinic esters together with a few related compounds; glycerides including a few of short chain acids and some vegetable oils; and some assorted aromatic esters. Only a small proportion of these were suitable for topical applications because of difficulty in accurately applying small volumes of the more viscous liquids from the micro-burette and because many exhibited toxic effects when applied topically.

Most effective solvents tested possess properties similar to the kerosenes and other petroleum products already extensively employed in the production of insecticidal sprays because of their availability and cheapness.

The following conclusions are given:

Chemical structure had a general influence on solvent efficiency. Providing that their physical properties were similar paraffinic hydrocarbons were better solvents than aliphatic long-chain esters and related compounds which in turn were better than aromatic esters.

Physical properties were of importance in determining efficiency within a group of solvents of similar chemical structure. Viscosity was an especially reliable guide as it presumably controlled the rate at which the solution could pass from the paper and on to and into the insects during the exposure period.

The solvents were in the same order of effectiveness when different insecticides were used but the ratio of median lethal concentrations varied greatly from one insecticide to another. Presumably the insecticide and solvent must pass through the cuticle to some extent independently of each other, and size and shape are limiting factors in the diffusion of insecticide molecules. The differences in ratios of median lethal concentrations between different solvents for the insecticides used also meant that the relative toxicities of the insecticides depended upon the solvent in which they were dissolved.

When some of the solvents used in filter paper tests were applied topically to the insects the differences in efficiency were greatly reduced, showing that an important influence of the solvents had been upon pick-up of insecticide from the papers. However, even with topical applications there were still some differences in median lethal concentrations and especially in rates of action between the solvents, thus providing further evidence that the solvent is also concerned with passage of insecticides through the insect cuticle.

The relative efficiencies of the solvents bore no relationship to the solubilities of the insecticides in them and it was concluded that in these experiments chemical potential was not likely to be a controlling factor.

57/59 STUDIES ON AQUEOUS SUSPENSIONS OF INSECTICIDES

A. B. HADAWAY and F. BARLOW. Colonial Pesticides Research Unit, Porton.

Part I.

In the first paper the authors record the testing methods used and results obtained in assessing the inter-relationship of particle size and insecticidal effectiveness. The preparation of plaster-of-paris test blocks for exposure tests, of sieving and sedimentation procedures for obtaining size ranges of the insecticide powders, and of the use and calibration of a Webb-type spraying tower for producing regular spray deposits, are described. Assessments of insecticidal effectiveness were based on mortalities of batches of Aedes aegypti L. females (2-3 days old) exposed for a short contact period, after one blood meal, to replicate series of blocks sprayed with suspensions of insecticide including pp' DDT, DDD, methoxychlor, γ BHC and the active constituent of dieldrin (HEOD). Densities and m.p.s. of the insecticides are listed. Biological tests were made, under standard conditions, at 25°C and 70-80% relative humidity. The influence of fillers and other components, as well as of the nature of the treated surface were investigated. The following conclusions are given:

There is an inverse relation between the size of ground DDT crystals fractioned into size ranges by sedimentation and their effectiveness. Smaller particles are more effective than larger ones even when equivalent numbers are compared. Differences in effectiveness are attributed to differences in the amounts of insecticide picked up and retained by the insect.

There is no significant increase in kills of mosquitos exposed for the same contact period to dosages of 10-20 micron DDT crystals above 3 mg. per sq.ft. "Persistence" of deposits of these crystals, however, increases as the dosage increases.

Crystal length alone is not critical, for fine 60 micron DDT needles are slightly more effective than ground crystals in the 10-20 micron range. The shape and mass of crystals together influence pick-up and determine their effectiveness.

There is also an inverse relation between crystal size and effectiveness of methoxychlor and DDD. The effectiveness of Compound 497 and of the gamma isomer of benzene hexachloride is influenced much less by particle size than is that of DDT.

The inert ingredient of a wettable powder has a masking effect on the insecticide, and this is intensified as the proportion of diluent to insecticide increases.

The availability of the deposit from an aqueous suspension of DDT crystals depends largely on the nature of the surface to which it is applied.

Part II. - Quantitative Determinations of Weights of DDT Picked up and Retained.

The second paper describes tests correlating the weight of DDT, picked up by mosquitoes and tsetse flies, in short contact periods from deposits on plaster blocks and other test surfaces, with corresponding mortality rates.

The insecticide was measured by a method based on that of Schechter and others. The mosquitoes used are described in paper I. The tsetse were *Glossina palpalis* R.D. (1-3 days old and unfed). Procedures adopted are similar to those already described. Conclusions are as follows:

The rate of action of DDT particles picked up by mosquitoes increases as the size decreases.

Taking into account the weights of insecticide picked up, the median lethal dosage increases as the particle size increases. A further factor, that of retention on the body of the insects, has to be considered, for there is evidence that adherence of particles in the 0-10 and 10-20 micron ranges is greater than that of larger particles. Availability, and therefore effectiveness, of deposits from aqueous suspensions of insecticide particles is influenced considerably by the type of material to which they are applied.

Part III. - Factors Affecting the Persistence of Some Synthetic Insecticides.

Factors affecting the persistence of deposits from aqueous solutions of insecticides are described. The persistence of insecticide crystals of different sizes is shown to vary considerably on different materials. The most striking results were obtained with certain mud blocks. Crystals of all insecticides tested disappeared rapidly from the surface of mud blocks, and even crystals of DDT, which is usually regarded as a contact insecticide with a long residual effect, disappeared from the surface at 78°F (25.5°C) in a matter of days leaving the mud surface non-toxic to mosquitoes. This remarkably rapid loss in toxicity on dried mud is of obvious importance in the control of adult mosquitoes in houses where the walls are constructed of this material.

Preparation of the mud blocks is described and details are given of an exposure test for assessing fumigant action of insecticides (e.g. γ BHC and aldrin). It is concluded that:

There is an inverse relationship between particle size of insecticides and the initial contact toxicity to mosquitoes. The influence of particle size on effectiveness decreases as the intrinsic toxicity of the insecticide increases. The compounds investigated can be arranged in order of immediate contact toxicity to mosquitoes (*Aedes aegypti*): dieldrin > gamma-BHC > aldrin > DDT.

There is a similar initial inverse relationship between particle size and fumigant effect because of the increase in surface area with decrease in size. The compounds can be arranged in order of fumigant effect on mosquitoes: gamma-BHC > aldrin > dieldrin > DDT.

These compounds are not repellent to mosquitoes if direct contact is prevented.

The larger the particle the longer it persists. For any given particle size, compounds can be arranged in order of persistence: DDT > dieldrin > gamma-BHC > aldrin.

The persistence of particles of these insecticides is influenced considerably by the type of material to which they are applied.

The discovery that insecticides were rapidly sorbed by dried mud, particularly red lateritic soil from Uganda, as used in house construction, was of great significance in the control of malaria vectors.

The outstanding features of these residual tests are listed as follows:

Particles of all four insecticides, DDT, gamma-BHC, dieldrin and aldrin, disappear very rapidly from the surface of mud blocks at dosages of 25 mg. per sq.ft.

When surface deposits are no longer visible toxicity is completely lost on DDT and dieldrin treated blocks but persists at a reduced level for many weeks on γ BHC and aldrin treated blocks.

Almost the whole of the dosage of 10-20 micron crystals of DDT and γ BHC can be recovered from the interior of the blocks.

There is ample evidence to show that the residual toxicity of blocks treated with γ BHC or aldrin is due to the fumigant effect from the material inside the blocks.

The rate of disappearance of particles from the surface of mud blocks decreases as the relative humidity of the atmosphere increases.

Commercial formulations behave on the different materials in the same way as the pure crystals.

Particles of all insecticides remain for a much longer time on plaster blocks and wallboards than on mud blocks. Plaster blocks and wallboards also retain some toxicity to mosquitoes after the disappearance of crystals of aldrin and γ BHC from the surface, but this toxicity is lost more rapidly than it is on mud blocks.

Part IV. - The Behaviour of Mosquitoes in Contact with Insecticidal Deposits.

Experiments described in this paper were to determine the behaviour of mosquitoes in contact with deposits formed by spraying aqueous suspensions of insecticides on to different materials. Test insects, allowed to alight individually, were timed to the first flight. The following conclusions are recorded:

A. stephensi females flew from all formulations of DDT on various materials after approximately the same time of 2 to 4 minutes, but subsequent kills were high only when the deposit consisted of small (less than 10 microns) particles readily available for pick-up.

Mosquitoes were also activated by contact with fresh deposits of BHC wettable powder P.520, but all died very quickly. They were not disturbed, however, by the vapour from BHC deposits, when contact was prevented, until in an advanced stage of intoxication. The time to the first flight from surface treated with BHC wettable powder increased as the deposits aged and varied with different materials according to the rate of loss by evaporation and/or sorption.

Mosquitoes remained in contact with deposits of chlordane, dieldrin, aldrin and toxaphene for more than 30 minutes.

Experiments with a number of DDT analogues and BHC isomers indicated that lipoid solubility and molecular structure are two factors governing the rate of penetration of a compound.

The reactions of other species tested were similar to those of A. stephensi but kills of C. molestus were significantly different from those of the anopheline species after contact with deposits from a DDT wettable powder.

Part V. - The Sorption of Insecticides by Soils

Miscellaneous items of work on the sorptive phenomenon are recorded. Observations of the actual process are of necessity based on a few qualitative tests.

It is suggested that if the vapour of an insecticide is rapidly adsorbed by a substrate the rate of volatilization of the molecules of insecticide particles lying on the substrate is greatly increased. This explains the rapid loss of effectiveness of wettable powders on some soils. After the insecticide has been sorbed it is concentrated at and near the treated surface but afterwards slowly diffuses inwards. This diffusion reduces recoveries of insecticides from surface scrapings.

A record is given of the condition of completely sorbed DDT in mud blocks, from analyses of successive layers of known thickness.

DDT can be recovered quantitively from Uganda mud blocks 12 months after sorption is complete. Therefore, on this mud at least catalytic decomposition does not occur. A test devised to measure the sorptive capacities of soil samples for non-polar vapours is described. It indicates whether or not a soil is highly active. Those with lower or negligible activities do not give a good correlation.

A survey of 18 soils from different parts of the world suggests that rapid inactivation of an insecticide by sorption should be expected on any red lateritic soil. Generally, others are inert or show only low activity.

A record is given of attempts to reduce or abolish the sorptive powers of Uganda soil. Limewashing was considered effective but pre-treatment with a size solution reduces the efficiency of a subsequently applied wettable powder.

Part VI. - Further Notes on the Sorption of Insecticides by Soils.

Quantitative measurements were made of the sorption of gamma-BHC and dieldrin in Uganda mud blocks using techniques described previously. Gamma-BHC diffused more rapidly than dieldrin, and within a few weeks had achieved an almost uniform concentration throughout the sprayed blocks. Only when the uniform concentration had been reached did loss by evaporation from the blocks became marked. Increased dosages of gamma-BHC gave increases in biological activity which were roughly proportional to the dosages used. Sorption on to mud greatly prolonged the residual life of gamma-BHC as compared with similar deposits on glass.

Dieldrin behaved in the same way as gamma-BHC although because of its slower rate of diffusion the distribution in the blocks had only reached in 48 weeks the stage that gamma-BHC had in 8 weeks. There was no appreciable loss of dieldrin during this time whereas about 90 per cent of the deposit on glass plates had been lost.

Gamma-BHC, dieldrin and DDT were recovered from the adsorbed state on mud and identified. Any decomposition is therefore likely to be negligible. Dieldrin was also recovered from two soils which had much higher "surface acidities" than the standard.

Concerning the sorption of insecticides by mud blocks from the vapour phase it was found that active mud can only sorb the portion of insecticide vapour from an evaporating deposit which happens to diffuse in its direction. This is to be expected but the system has some peculiarities because the evaporation of gamma-BHC from filter papers over mud blocks is much faster than in the absence of the mud.

Measurements of the distribution of DDT and dieldrin in soils less active than the standard Uganda one showed that both the initial adsorption and subsequent diffusion were very much slower.

The activity of Uganda soil was not reduced by removal of material soluble in organic solvents, and was only partly reduced by complete extraction of iron compounds.

Variations in temperature over the range 20 to 30°C had only small effects on the diffusion of DDT and dieldrin within mud blocks.

Repeated applications of DDT and dieldrin to the same blocks did not result in any observable slowing in the rate of disappearance. The concentration of insecticide in the successive layers of mud, did, of course, increase with successive sprayings.

Part VII. - The Influence of Relative Humidity upon the Sorption of Insecticides by Soils.

This paper gives account of a more detailed investigation into the influence of humidity on the sorption of soils by dieldrin, gamma-BHC and DDT. In agreement with field observations, kills of mosquitoes increased as the humidity increased and this effect was rapidly reversible.

The authors conclude that disappearance of insecticide particles from the mud surface is inversely related to humidity, the rate increasing as humidity decreases. On the other hand, the rates of diffusion of sorbed insecticide away from the surface are greater at higher humidities.

They suggest that when the biological activity of a mud surface is increased by increasing the humidity, the insects acquire a greater dose of insecticide not because the concentration of insecticide in the surface layers is greater but because the insecticide that is already present acquires a greater mobility. This greater mobility results in a more rapid diffusion in the mud itself away from the treated surface and a greater potential for diffusion into insects resting on the mud surface.

Support for these conclusions was obtained by showing that on transferring dieldrin-treated mud blocks from low to high humidity the change in biological activity occurred at about the same rate as the increase in water content of the blocks.

The influence of humidity upon the sorption of DDT and dieldrin on a selection of soil samples of widely differing origin was observed. Both insecticides disappeared more rapidly at low than at high humidity on all the soils.

57/60 NOTES OF TESTS OF SCENT ATTRACTANTS FOR TSETSE FLIES

W. P. LANGRIDGE. Veterinary Research Laboratory.
Kabete, Kenya.

Various substances, tested as olfactory stimulants against Glossina pallidipes, are reported. Preliminary laboratory tests, involving apparatus similar to that described by Mrs. J. C. Hughes, show ethyl caprate and octyl acetate, which was toxic when concentrated, to be markedly active.

Field observations, carried out at Kiboko, were based on "Transect" and "Diagonal" methods of testing. The "Transect" test was in use to determine whether a wider distribution of scent would more effectively attract flies. It consists of partitioning narrow strips of pathway, cut through infested bush, into sectors of length approximately 50 yds. Traps are placed in the first, third, fifth, etc. sectors; attractant is applied by spray or smear to alternate trap sectors at the rate of $\frac{3}{4}$ gallon every second day; at the same time traps are moved to alternate ends of treated or non-treated sectors. Treated control sectors are inter-changed after eleven days.

"Diagonal" testing utilises two traps, placed at opposite corners of a square (side 200-400 yds), one of which is sprayed with attractant. Traps are moved anti-clockwise every second day into adjacent corners, fresh attractant being applied after each complete cycle.

Present indications are that ethyl caprate, lanolin, dried shark meat extract and the emulsifying agent in Dieldrex 15 act as attractants; lauryl acetate and ethyl laurate may act as repellents.

57/61 THE CONTROL OF AN ISOLATED TSETSE POPULATION

B. HYDE-WYATT. (Late Research Assistant, Department of Tsetse Control, Ghana.)

The station garden at Wa provided the site for experiment. About 5 acres in extent, its plantations of Mango, Guava and Citrus fruits and its two sacred crocodile pools provided a breeding place for Glossina tachinoides West.

In October 1956, when the number of tachinoides teneral* and post teneral flies captured in Morris traps was 89, all vegetation that could provide cover for the flies was sprayed with DDT wettable powder at the rate of 1 lb in 8 gallons water per acre, from a pressure retaining knapsack sprayer.

A reduction in the number of flies was observed within the first week and subsequent catches remained at a low level (see table below).

It is concluded that for small isolated areas where clearing is not practicable this species of tsetse may successfully be controlled by the use of insecticides.

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* Flies under 7 days old.

G. tachinoides. Wa Station Garden

Date	Teneral			Post Teneral			Grand Total	DDT Applied
	M	F	Total	M	F	Total		
1956								
August	2	1	3	19	21	40	43	
September	12	24	36	19	29	48	84	
October	7	10	17	30	42	72	89	30th
November	0	2	2	1	4	5	7	5th
December	0	1	1	0	6	6	7	5th: 17th
1957								
January	0	0	0	0	0	0	0	
February	0	0	0	0	2	2	2	

57/62 COLONIAL TERMITE RESEARCH UNIT, WEST AFRICA. REPORT FOR THE QUARTER ENDING 31st MARCH 1957.

Termite collections for N. Nigeria contain 65 species from over 30 genera. One genus is probably new to science related to *Ophiotermes* Sjöstedt.

Damage

Groundnuts were damaged mainly by *Microtermes*, K50 variety suffering severely, but native spreading varieties much less.

At Kano *Eucalyptus citriodora* was attacked by *Macrotermes*, with minor attacks on moribund saplings by *Coptotermes*, *Microtermes* and *Microcerotermes*. In Zaria *Macrotermes* and *Pseudacanthotermes* girdled and felled young *Eucalyptus*. At Jos attack by *Macrotermes* and *Pseudacanthotermes* was prominent, with minor attacks by *Ancistrotermes* and *Microcerotermes* on previously damaged trees. Where plantations followed long-term native cultivation on very poor gravelly soils over a hard pan about 9" below the surface no attacks by *Macrotermes* or *Pseudacanthotermes* were found, but a very small number of year-old samplings were killed by *Microtermes*. On flattened tailing dumps from tin mines, trees 3-6" diam. had been girdled by *Macrotermes*, but were surviving. In un-levelled dumps no damage was found. At Bauchi, *Eucalyptus* was destroyed by *Macrotermes*.

Where it occurs *Macrotermes* is the most rapidly destructive genus. *Pseudacanthotermes* covers a more limited area round the nest, proceeds more slowly, but still produces severe damage. *Microtermes*, *Ancistrotermes*, *Odontotermes* and *Microtermes* attack is seldom fatal, but causes deformation and reduction in timber value.

Other trees damaged include Flamboyant by *Odontotermes*; Neem by *Macrotermes*; *Dalbergia* and *Cassia* by *Microtermes* and *Microcerotermes*.

Control

Control experiments are in hand and results will be reported later.

57/63 A NEW METHOD OF TESTING MATERIAL AGAINST CRYPTOTERMES ATTACK

W. WILKINSON. Termite Research Unit, Port Harcourt, Nigeria. Jan. 1957.

A new method of inducing attack by primary pairs of *Cryptotermes havilandi* (Sjöst.) on timber is described.

A trap consisting of a 70 cm. diameter white enamel bowl, 10 cm. above the bottom of which is suspended a 60 watt bulb, is used. A 45 cm. plywood disc, supported by blocks or the specimens under test is placed at the bottom of the bowl allowing sufficient room for the termites to pass between the edge of the disc and the side of the bowl. The bottom of the bowl is painted black.

The alates of *C.havilandi*, which fly mostly after dark and are positively phototactic, are attracted to the light and fall into the bowl. After shedding their wings they become negatively phototactic, pass below the disc, and enter the test blocks.

The test blocks, which should not be smaller than 1½" x 1½" x ½" which allows sufficient pabulum for the colony to advance to an age when its degree of success may be assessed, are placed below the disc. Each should have a hole, one of 2.4 mm. (3/32") x 13 mm. (½") having been found most successful.

The bulb can be left on all night, but observations during December show that over 50% of the alates fly between 1800 and 1900 hours. Most of the pairs will have sealed themselves in by morning, when the occupied samples may be removed and stored. The presence of termites will be shown by a dark brown seal in the hole, though this is not always at the outer wood surface.

The apparatus will gladly be loaned to Tropical Testing Establishments for any tests they may wish to make.

57/64 INTERIM REPORT OF A SURVEY OF NEMATODE DISEASES OF EAST AFRICAN CROPS PRESENTED AT THE SPECIALIST COMMITTEE ON AGRICULTURAL BOTANY HELD AT ARUSHA FROM 28th-30th MAY, 1957.

A. G. WHITEHEAD, East African Agriculture and Forestry Research Organisation.

The results of field and laboratory studies in the first eight months of a survey of plant nematode diseases have shown that a wide range of known and suspected nematode parasites commonly occurs in cultivated soils of East Africa. Nematode attacks of the crops of East Africa are both numerous and widespread and a large number of cultivated plants including most of the major economic crops have to date been found susceptible. Nematode damage appears to be considerable and widespread.

The following genera of parasitic and suspected parasitic nematodes have so far been discovered:-

Meloidogyne spp. (Root-knot nematodes)
Pratylenchus spp. (Root-lesion nematodes)
Hoplolaimus spp. (Lance nematodes)
Ditylenchus spp. (inc. Stem eelworm)
Paratylenchus spp. (Pin nematodes)
Rotylenchus spp. (Spiral nematodes)
?*Rotylenchulus* sp. (Reniform nematode)
Tylenchorhynchus spp.
Tylenchus spp.
Tylenchulus sp. (Citrus eelworm)
Aphelenchus sp.
Aphelenchoides spp.

Criconema spp. (Ring nematodes)
Criconemoides spp. (Ring nematodes)
Longidorus spp.
Xiphenema spp.

also various genera belonging to the family Neotylenchidae Thorne 1941.

Many species of the above genera are new species and will be described in full in due course.

The following crops have so-far been found attacked by parasitic nematodes:-

Banana
Carnations
ø Coffee (arabian)
ø Cotton
ø Maize
Narcissus
Passion fruit vine
Pawpaw Papaya
Phaseolus vulgaris var.
'Canadian Wonder
ø Pineapple
ø Potato
ø Pyrethrum
Russian Comfrey
ø Tea
ø Tobacco
Tomato
ø Wattle
ø Wheat

Vegetables:-
Parsnip
Carrot
Lettuce
Celery
Beans (various)

The problems of main economic importance are marked with an asterisk, as above. In view of the range of crops attacked, of the interchange of infested material within the three territories and ever increasing demands on the land the seriousness of the damage is likely to increase. Control measures are at present difficult to carry out or very expensive and a great deal of information is required before adequate measures can be implemented. Consequently much intensive research will be required in the next few years if the situation is to be improved. Moreover the dangers of importing a variety of obnoxious nematode parasites, not yet found in East Africa, are considerable and extremely careful watch must be kept through the East African Plant Quarantine Station. Already a very harmful species of the genus Aphelenchoides Fischer has been intercepted in this way, which would have caused considerable damage had it been released in to East Africa.

57/65

PEST CONTROL RESEARCH AT WEST AFRICAN COCOA RESEARCH INSTITUTE

D. J. TAYLOR. West African Cocoa Research Institute.

Capsid Control

After laboratory tests had shown that aldrin and dieldrin compared very favourably with gamma-BHC in the rapidity with which they killed caged capsids, experiments were set out to determine the relative value of aldrin, dieldrin, endrin, heptachlor and gamma-BHC under field conditions. The experiments were started in August 1956 and concluded in March 1957.

Emulsifiable concentrate formulations were used. Each treatment consisted of two low-volume applications of the insecticide, the first in late August or early September and the second eight weeks later. On each occasion 2 oz. of the actual toxicant in five gallons aqueous wash were applied per acre with a motorised "Motoblo" mistsprayer. The treatments were randomised amongst plots located in farmers' cocoa in the Eastern Region of Ghana. Comparatively large plots (approximately five acres) were used to ensure that each contained a similar amount and range of capsid damage, including recent attack indicating the presence of capsids, and also pockets of acutely damaged and cankered trees with little or no canopy. The treatments were replicated three times. The effectiveness of each insecticide was measured by counting the number of trees damaged by capsids following the insecticidal applications. This assessment was carried out by a gang of observers which swept backwards and forwards through each plot looking for newly formed capsid lesions. Trees suffering from recent damage were labelled and recorded. The first assessment was carried out six weeks after the first application of insecticides, the second assessment six weeks after the second application, and further assessments at fortnightly intervals thereafter. The results are summarised in Table I.

TABLE I

Insecticide Trials

	Number of damaged trees per acre (Mean for three replicates)						
Weeks after first application	6	14	16	18	20	22	24
Endrin	1.4	1.4	1.5	1.9	2.6	3.7	3.9
Gamma-BHC	7.2	8.0	8.5	9.8	12.2	12.8	15.3
Aldrin	7.5	9.7	11.9	12.9	14.1	15.8	18.4
Dieldrin	6.6	8.9	9.9	11.7	14.2	17.8	20.1
Heptachlor	100+						

It is clear that plots sprayed with endrin suffered far less damage than the other plots, and excellent control and protection was obtained with subsequent regeneration of damaged trees. Heptachlor did not give adequate control. Good control of capsids followed by the regeneration of the damaged trees was observed in plots treated with gamma-BHC, aldrin and dieldrin. The amount of subsequent fresh damage was very small and of the same order with each of these insecticides. Even after six months the number of damaged trees was less than 20: the significance of this is more readily appreciated when it is realised that the tree density of farmers' cocoa is between 500 and 600 per acre.

Of the four effective insecticides at the present time aldrin is the cheapest, while gamma-BHC is approximately two and a half times and endrin approximately three times as expensive. It is possible that further work on frequency and rate of application of endrin might indicate that control could be achieved more economically with this insecticide.

Methods of Application of Insecticides

Preliminary examination and trials indicated that a pressure-retaining pneumatic knapsack sprayer, fitted with a long bamboo lance and a low-volume nozzle (such as the "Leo-Colibri No. 8 of Messrs. Cooper, Pegler & Co. Ltd.) possessed several of the qualities required for use on cocoa in Ghana. This type of sprayer has normally a working capacity of two gallons and may be used at a pressure of up to 100 p.p.s.i. This high working pressure gives very good atomisation of the insecticide, and released some 20 feet up a fine insecticidal mist drifts through the canopy. The output can be varied from approximately four to 14 gallons per hour by using nozzle caps with different sized apertures in conjunction with fine or coarse spiral internals. In trials, using the rubeanic acid-copper test for the detection of spray deposits, it was found that good coverage of foliage at all levels in mature cocoa was obtained by applying five gallons insecticidal wash per acre. In typical farmers' cocoa one man with one machine, spraying at the rate of five gallons per acre, was able to cover the ground at the rate of one acre per hour and a quarter. Tested in field-scale trials this equipment has given satisfactory results with gamma-BHC, dieldrin and aldrin.

Swollen Shoot Disease Vector Control

Previous work on the control of Pseudococcus njalensis Laing, the main mealybug vector of swollen shoot, with contact insecticides, has met with little or no success. The ant-constructed tent or carton covering the colonies affords protection from direct spraying, and efforts to disrupt the ant - mealybug association through the control of ants by manual removal of nests, grease-banding and the application of DDT or BHC sprays have also given unsatisfactory results. It appears that in previous insecticidal trials the toxicants used have been poor formicides and that the dosage rates have been too low.

Dieldrin, which has proved a highly residual insecticide effective against ants in other parts of the world, was used in preliminary experiments set up in farmers' cocoa. All cocoa and forest shade trees were sprayed with a 1 per cent dieldrin aqueous emulsion with a "Motoblo" motorised sprayer at the rate of 10 gallons per acre (i.e. 1 lb. toxicant per acre). Trees were individually treated, the spray being directed to the lower 8 to 10 feet of the trunk. Surveys of ant activity were made before the insecticidal application, and further weekly surveys were carried out thereafter. At each survey all trees, including forest trees, were examined from the ground and a record made of all ant species seen and their relative abundance and activity.

A spectacular reduction in the ant population occurred immediately after spraying; organised ant activity such as the typical columns of workers moving up and down tree trunks, were completely disrupted. The vast majority of nests became moribund with the depletion of the mobile worker caste, though this took several weeks with some of the larger nests of Crematogaster spp. After a period varying in the different plots from four to eight weeks, reinfestation began, partly from nests which had not been completely eliminated and partly from the cocoa outside the plots. Re-establishment of organised ant activity took very much longer and neither of the two main groups of mealybug-attending ants, the Crematogasterini and the Pheidolini, had re-established themselves after 28-30 weeks. Oecophylla, one of the dominant ants of cocoa, however, became well established about 16 weeks after spraying, and increased rapidly during the following two months. Another leaf nesting ant, Macromiscoides, also became re-established after some 16 weeks. Neither of these species attend mealybug colonies (or, at the most, only on very rare occasions), and both species are said to be inimical to the mealybug-attending ant groups.

TABLE II

Effect of Dieldrin on Different Ant Groups

	No. of trees observed with organised ant activity			
	All species	Cremato-gasterini	Pheidoli-ni	Oecophylla
Initial survey	231	112	28	80
1st weekly survey	7	0	0	4
2nd weekly survey	4	0	0	2
4th weekly survey	10	2	0	7
8th weekly survey	24	2	0	27
16th weekly survey	77	4	1	62
24th weekly survey	129	11	1	103

In this experiment, at least, no attempt was made to spray the canopy, though clearly some of the insecticidal mist would drift upwards giving immediate kill but little or no residual effect.

Within a few days after spraying the mealybugs, which with the elimination of the ants were no longer being attended, became covered with droplets of their own honeydew secretion. The ants normally remove this secretion from the anal orifice of the mealybug as it is produced. After a week many of the colonies were covered with a layer of fungal and bacterial growth which rapidly developed on the honeydew, and which in many cases was followed by the death of the adults and the eradication of the colony.

It can be seen that the ant population of cocoa can be practically eliminated by the application of dieldrin to the tree trunks, and this is followed by a very great fall in the mealybug population. Further work on this is in hand, including experiments involving the application of malathion after the dieldrin, to deal specifically with the surviving mealybugs.

57/66 CONTROL OF CAPSID PESTS OF COCOA

G. S. COTTERELL. Extracted from 1955-56 Annual Report of the Department of Agricultural Research, Federation of Nigeria.

Large scale insecticide trails have been carried out on mature cocoa using spray formulations of 4 ozs. and 6 ozs. of gamma BHC in 5 galls. water per acre, applied by power operated low-volume shoulder-mounted sprayers, and dust formulations (0.65% gamma BHC) of 20 lbs. of crude dust containing 2 ozs. gamma BHC per acre.

Since the first spray application, no capsid damage had been observed, and the only leaf-blast seen has been due to old damage. Good control was also obtained with dust but some damage was observed. This method suffers from the drawback, under Nigerian conditions, that dust may not be retained in the canopy, owing to high temperature conditions. It is necessary to stop dusting operations after about 10 a.m. on cloudless days, whereas spraying operations can be continued throughout the day. There are indications of yield increases following capsid control, with subsequent tree regeneration.

Figures obtained show the capsid incidence commences to rise in August. Treatment with gamma BHC (lindane) at 4 ozs. per acre commenced in August 1955 and continued at approximately one monthly intervals to February 1956. The capsid population on the treated plot dropped to 'nil' at the first spraying and remained so, whereas on the untreated plot it rose to a maximum of 150 bugs per 100 trees by mid-January. The regeneration on the contiguous untreated plot became noticeable by November.

Records from a large scale trial at Akola (near Ilesha) have been continued, treatments of 5% DDT at 20 lbs. per acre were applied in August, and subsequently when capsid population exceeded 40 per 100 trees. This figure was only exceeded once during the year, necessitating additional treatment.

Observations on a plot at Ajoue indicate that once capsids have been controlled the effect may last for some years.

Complete control of capsids in mature cocoa has been obtained by monthly low-volume spray applications from August to February at 6 ozs. gamma BHC per acre. .

57/67 USE OF PAPER BAGS FOR COCOA STORAGE

Annual Report, 1956, West African Stored Products Research Unit.

Small scale preliminary experiments indicated that cocoa stored in multiwall paper bags appeared immune to external insect attack, and did not suffer mould damage in excess of that occurring in standard hessian bags under similar conditions.

A mixed heap of Grade I cocoa was bagged into six standard hessian bags and nine multiwall paper bags (three each of three different types) and stored together for three months, being exposed to the usual type of cross-infestation. All the paper bags, and three of the hessian bags, were fumigated.

Results of insect infestation are tabulated below. The populations of the fumigated and unfumigated hessian bags were very similar.

	Multiwall Paper Bags (Av. of 9 bags)	Normal Hessian Bags (Av. of 6 bags)
Lasioderma serricorne Fabr.	0	5.2
Tribolium castaneum Herbst.	4.3	13.5
Ephestia cautella Wlk.	0	1.8
Oryzaephilus mercator Fauv.	0	1.1
Laemophloeus sp.	0.4	1.8
Carpophilus sp.	0	0.4
Parasites	0	1.0
Total Insects	4.7	24.8

It was concluded that if cocoa in paper bags was fumigated it could be stored for three months without becoming seriously damaged. Practical commercial difficulties might be overcome by the use of hessian bags with a multiwall paper liner.

57/68 ENTOMOLOGICAL RESEARCH ON PREMATURE NUTFALL OF COCONUTS IN THE BRITISH SOLOMON ISLANDS. ENTOMOLOGIST'S PROGRESS REPORT No. 3

Experiments have been carried out on the use of insecticides to reduce mutfall both by directly controlling Amblypelta and indirectly by controlling non-beneficial ants associated with it.

Results so far indicate that insecticides have little residual effect on living spadices and fronds, and reliance can be placed only on direct contact effects. Sprays need to be repeated at approximately monthly intervals, but further work is required to determine the number needed to reduce nutfall to negligible proportions.

Ant control has not given encouraging results so far, partly due to the fact that Iridomyrmex, the most important nutfall ant, is very intractable to any practicable insecticide treatment. Also there is so far no evidence that, should it be reduced, other beneficial ants will readily move in to replace it.

Attempts at control of Iridomyremex myrmecodiae using poison bait showed that spectacular results could occasionally be obtained, but the method was completely unreliable.

57/69 GATOOMA RESEARCH STATION, SOUTHERN RHODESIA. COTTON PEST RESEARCH SCHEME MONTHLY REPORTS FEBRUARY-APRIL 1957

Diparopsis

The final results of the 1955/56 season's pupation experiments on Diparopsis are summarised in Table I.

Two tentative conclusions are suggested:-

1. The first diapause pupae are formed from larvae entering the soil early in March. By the end of April virtually all the pupae formed entered diapause.

2. Diapause pupae formed early in the season enter a considerably longer pupal period than those formed in June and July.

In the 1956/57 Field Pupation Experiments the sampling of cages set up from February 4th to March 25th has shown a high pupal mortality, ranging from 20% to 60% as a result of ants, at present unidentified, occuring in the pupation garden.

Experiments on the chemical control of *Diparopsis* using DDT + BHC, and endrin at various concentrations and applications have been set out.

Dysdercus

From the evidence available it seems fairly clear that the host-plant food cycle of *Dysdercus* is as follows:-

September:	*S.africana* (Ngoza) fruits first became available. No other arboreal host suitable except for a few *A.digitata* and *T.garckeana* with old seeds.
October;	As September *S.africana* fruits more numerous and more available.
November:	As October. This months and December peak months for availability of fruits of A *S.africana.*
December:	As November.
January:	About the middle of the month (this year) *S.africana* fruits were mostly dried out although much seed was still available for *Dysdercus.* However, the green seed appears to be preferred. By the middle of the month (this year) some of the early planted cotton had formed bolls and migrations to these gardens took place from time to time as the *S.africana* became unsuitable. At this time of the year there was still no other host suitable although without cotton *Dysdercus* would still survive on the old seed of *S.africana* and *A.digitata* (Baobab:Mlambe) and might possibly live on *Hibiscus.* Under these circumstances, however, little multiplication would be expected and breeding would be almost nil.

February:	Cotton almost only host apart from old seed on *S. africana* and *A. digitata*. Both *S. appendiculata* (Njale) and *A. digitata* starting to flower.
March:	Cotton virtually only host. Very few *S. appendiculata* in fruit, many *A. digitata* in fruit. Fruits not yet available to *Dysdercus* in both.
April:	Cotton supporting almost all the *Dysdercus* population but a few *S. appendiculata* now suitable.
May:	Cotton, many *S. appendiculata* (?) and some *A. digitata* (?).
June:	Some cotton still suitable; many *S. appendiculata* and *A. digitata* suitable (?).
July:	Mostly now on *A. digitata* and less on *S. appendiculata*. *Thespesia garckeana* and *S. quinqueloba* possibly suitable (?). Cotton seed (stored).
August:	*A. digitata*; *T. garckeana* (?); *S. quinqueloba* (?).

From the above it can be seen that, by growing cotton as at present, the first of the crop begins to mature just as the main, almost only, alternate host is waning. Thus the population that has built up on a plentiful food supply that is widely distributed (*S. africana*) during the early rains suffers little set-back but can readily migrate to the cotton where it finds sufficient food. On the other hand when cotton was not sown until March or April then this very large population died down completely, there being no suitable breeding host.

Experiments on the chemical control of *Dysdercus*, using 50% dieldrin wettable powder applied at a concentration of 0.5% at 30 galls/acre, and 40% aldrin wettable powder applied at a concentration of 0.5% at 30 galls/acre, were set out. Both insecticides were giving a high kill in April, 3 months after treatment.

TABLE I

RESULTS OF 1955/56 SEASON FIELD PUPATION EXPERIMENTS

Date 5th instar larvae collected	No. larvae entered soil	Non-diapause pupae No. moths emerged	Diapause pupae No. moths emerged	Total moth emergence	% total mortality	% moth emergence from diapause papae
2.2.56	55	25	0	25	54.5	0
9.2.56	88	28	0	28	68.2	0
19.2.56	25	10	0	10	60.0	0
24.2.56	97	61	0	61	37.1	0
13.3.56	100	48	6	54	46.0	11.1
19.3.56	150	45	12	67	55.3	17.9
5.4.56	150	15	18	33	78.0	54.5
10.4.56	150	1	38	39	74.0	97.4
17.4.56	150	0	0	0	100.0	-
28.4.56	150	1	0	1	99.5	-
15.6.56	89	0	37	37	58.4	100.0
2-6.7.56	26	0	14	14	46.1	100.0

57/70 COTTON PEST RESEARCH SCHEME, GATOOMA

The following is extracted from the monthly reports for June and July 1957.

Chemical Control of Diparopsis

The picking and classification of cotton from the two insecticide trials at Gatooma has been completed and an analysis of the results is in progress.

Yields of seed cotton for the various treatments are given in the following two tables:-

TABLE I

Insecticide Trial I

	Treatment	Yield seed cotton lbs/ac.	% staining
1	10% DDT + 3% BHC dust. Rate 10 lbs/acre 8 applications weekly from 1st buds	497.5 lbs	16.9
2	10% DDT + 3% BHC dust + sticker. Rate 10 lbs/acre 8 applications weekly from 1st buds.	393.6 lbs	20.4
3	19.5% endrin emulsion. 0.25 lbs in 10 gallons/ac. 8 applications weekly from 1st buds	759.9 lbs	15.8
4	19.5% endrin emulsion. 0.25 lbs in 10 gallons/ac. 8 applications over 12 weeks from 1st buds.	789.6 lbs	12.3
5	19.5% endrin emulsion. 0.25 lbs in 10 gallons/ac. 8 applications weekly from boll infestation.	835.2 lbs	9.2
6	No treatment. Control.	309.2 lbs	16.2

Least significant difference = 179.2 lbs/acre.
(P=0.05)

TABLE II

Insecticide Trials II

	Treatment 19.5% endrin emulsion sprays from 1st buds.	Yield seed cotton/acre	% staining
1	13 applications. 0.25 lbs in 10 gallons water/acre	1792 lbs	9 0
2	5 applications. 0.25 lbs in 10 gallons water/acre	1148 lbs	17.4
3.	5 applications. 0.25 lbs in 10 gallons water/acre and 8 applications 0.25 lbs in 20 galls water/acre	1616 lbs	8.9
4	5 applications 0.25 lbs in 10 gallons water/acre and 8 applications 0.50 lbs in 20 galls water/acre	1647 lbs	5.7

Least significant difference = 228 lbs/acre.
(P=0.05)

A full discussion of these results will only be possible when all the records of insect population and insect damage have been fully analysed. However, it is apparent from the results given in Table I that the endrin applications have given a considerable increase in yield over the control. It may be mentioned here that due to interaction between treatments the yields cannot be compared with those obtained from the observation plots.

Dysderous Control

The treatments used were as follows:-

Treatment A = 50% dieldrin wettable powder applied at 0.5% at 30 galls/acre.

Treatment B = 40% aldrin wettable powder applied at 0.5% at 30 galls/acre.

The first and second pickings on the treated and control plots have been made. The second picking was comparatively small.

Table III below gives the weight in pounds of seed-cotton picked.

TABLE III

Treatment	Grade 1	Grade 2	Total
1st Picking			
Control (no treatment)	106	119.2	225.2
Treatment A	121.1	121.8	242.9
Treatment B	300.2	356.1	656.3
2nd Picking			
Control	30.8	56.3	87.1
Treatment A	26.1	51.1	77.1
Treatment B	57.5	66.5	124.0
Total Results			
Control	136.8	175.5	312.3
Treatment A	147.2	172.9	320.1
Treatment B	357.7	422.6	780.3

It can be seen from the above table that in each case more than 50% of the cotton was grade 2, and that there was no significant difference between yields of control and treatment A. In treatment B, however, a yield was obtained that was 2½ times that of the control.

The results of this experiment are not what were expected. It was expected that while there would be considerable differences in the amount of Grade 2 cotton there would be little difference in yields. The reverse is the case. It therefore appears that application of aldrin increased the yield by 2½ times.

The recovery of Dysdercus dead from the treated plots (weekly collections) is given below:-

TABLE IV

Total Collection of Dysdercus dead from Sprayed Plots (Adults only)

February to June	D.intermedius	D.fasciatus	D.nigrofasciatus
Dieldrin (A)	440	78	56
Aldrin (B)	946	670	211

Total for A treatment : 574
Total for B treatment : 1,827

Live populations are shown in Table V where populations on 5 control plots, 5 plots of treatment A and 5 plots of treatment B are given.

TABLE V

Counts of Dysdercus on 5 Plots of each Treatment and Control

February to June	D.intermedius	D.fasciatus	D.nigrofasciatus
Control	2,279	946	39
Dieldrin (A)	1,164	545	12
Aldrin (B)	727	568	37

Totals: Control : 3,264; Dieldrin (A) : 1,721;
Aldrin (B) : 1,332.

A further analysis of the results showed that not only was the mortality of Dysdercus higher on the aldrin plots but the mortality of the majority of the other species or groups of insects found was also higher, and there was also an indication that bollworm infestation was reduced.

The experiment cannot be regarded as a very satisfactory one, however, since the aldrin plots were all interplanted with *Sorghum* and the effect of this cannot be determined. It seems possible that although there was an increase in yield due to the application of the insecticide, the total increase may not have been entirely due to this.

57/71 A PRELIMINARY NOTE ON THE CONTROL OF THE RED BOLLWORM, DIPAROPSIS CASTANEA, WITH INSECTICIDES

K. S. McKINLAY. Colonial Pesticides Research Unit, Arusha, Tanganyika.

Preliminary experiments on the insecticide control of *D.castanea* were carried out at the Colonial Development Corporation's Swaziland Irrigation Scheme during 1956/57.

The following treatments were compared:

Treatment A	DDT 1 lb/acre/application
" B	DDT 2 lb/acre/application
" C	DDT 1 lb, BHC $\frac{1}{4}$ lb/acre/application
" D	DDT 2 lb, BHC $\frac{1}{2}$ lb/acre/application
" E	Endrin $\frac{1}{4}$ lb/acre/application
" F	Endrin $\frac{1}{2}$ lb/acre/application
" G	Gusathion 1 lb/acre/application
" H	Untreated control

The treatments were applied as low volume sprays in 12 gals. of spray per acre, using hand operated knapsacks. Spraying commenced as soon as any bollworms entered the field, but finished before the end of bollworm attack because the vegetative growth of the cotton had become too thick and lush for the sprayers to get through it. Ten applications were made at weekly intervals between 28/11/56 and 31/1/57.

Damage was assessed by weekly counts of flared squares (flower buds damaged by bollworm). After 11/1/56 even the best treatment stopped giving good control and this was felt to be due to the inability of low volume sprays to give complete coverage once the cotton plants were tall and thick.

TABLE 1

Total numbers of flared squares counted in five counts between 18/12/56 and 15/1/57 on five replications of each treatment examining two 22 yd rows per replicated at each count.

H	A	C	G	B	D	E	F
215	110	90	85	75	75	70	40

Least significant difference, 5% level, 55.

As well as red bollworm, American bollworm (Heliothis armigera) and spiny bollworm (Earias sp.) were present.

TABLE 2

Green bollworm sample between 11/2/57 and 16/2/57. Two 22 yd rows of each treatment.

Treatment	Green Bolls		Living Bollworm Larvae		
	Clean	Damaged	Red Bollworm	Spiny B.W.	American B.W.
A.	1830	261	86	4	0
B.	1215	115	27	2	0
C.	1600	456	84	10	1
D.	1264	162	41	4	0
E.	1826	57	12	0	0
F.	1997	57	6	0	0
G.	1583	171	42	2	1
H.	848	156	46	2	1

The green boll sample demonstrated clearly that red bollworm was the most common species and showed once again that the endrin treatments, E and F, were the most effective.

During a dry period in December cotton aphis, Aphis gossypii, tended to build up and counts were made to determine the intensity of the aphis attack on the various treatments. Analysis of the aphid counts is given in Table 3 below.

TABLE 3

Numbers of plants showing medium to heavy aphid infestations in 176 yards of row per treatment.

A.	B.	C.	D.	E.	F.	G.	H.
45	73	16	14	8	1	1	42

Analysis of the detailed records showed that DDT with the addition of BHC, endrin or Gusathion, treatment C, D, E, F, and G were significantly different from A, B and H at 5% level. The most important point is, of course, the demonstration that if endrin is used for red bollworm control there will be little or no risk of aphid attack.

A second trial was carried out where a 0.025% endrin emulsion and a 0.1% malathion emulsion were applied to run-off in order to check that, given adequate coverage, endrin was an effective insecticide.

TABLE 4

Total living larvae found on five 22 yd rows of each treatment on 22/3/57 after six weekly applications of each insecticide.

Treatment	Red B.W.	American B.W.	Spiny B.W.
0.025% endrin to run-off	0	0	0
0.1% malathion to run-off	15	10	3
Untreated control	93	56	10

The indications are that given really adequate spray coverage endrin could give complete control of all three species of bollworm.

DDT, with or without BHC can only be expected to be moderately effective against this pest. With good coverage, endrin at $\frac{3}{8}$ to $\frac{1}{2}$ lb per acre at weekly intervals during the attack will undoubtedly give good control of red bollworm but caution would be necessary before recommending this insecticide since the latest figures show that its mammalian toxicity approaches that of parathion. Malathion, whilst not so effective is cheaper than endrin and at least as safe as DDT.

57/72 CONTROL OF RED-LEGGED EARTH MITE HALOTYDEUS DESTRUCTOR (TUCK) IN PASTURE. (AUTHOR'S SUMMARY)

M. M. H. WALLACE. Commonwealth Scientific and Industrial Research Organisation, Australia. Division of Entomology, Technical Paper No. 1. 1957.

Excellent control of the red-legged earth mite Halotydeus destructor was obtained in small hand-dusted ungrazed pasture plots with both DDT and BHC applied as mixtures with superphosphate. Late summer application of DDT at rates as low as 4 oz. pp' DDT in superphosphate per acre achieved good control of mites hatching with the subsequent autumn rains; higher concentrations were required in order to maintain control until the end of the season. A rate of 1 lb. DDT per acre continued to restrict mite numbers for two seasons after treatment, and an application of 4 lb. per acre kept the mite population at a negligible level for up to three seasons. Winter treatment at rates as low as 1.6 oz. DDT per acre achieved good initial control, but higher rates were required in order to maintain control for more than one season. An application of 4 lb. DDT per acre shortly after the hatching of the aestivating eggs maintained control into the fourth season. Late summer or early autumn application of BHC at the relatively high rate of 4 lb. per acre crude BHC in superphosphate was effective in controlling autumn hatching mites, but only when applied not more than a month before their appearance. Winter treatment at the more economical rate of 8 oz. per acre achieved good initial control but residual control was limited.

Large-scale distribution of DDT by broadcaster or drill-farm implements usually employed for superphosphate distribution - was not as effective as the small-scale hand applications. Late summer treatment using these implements with 1 lb. pp' DDT in superphosphate per acre gave a satisfactory kill when the mites hatched in the autumn, but the residual effects were poor. An application of 2 lb. DDT per acre by drill gave very good results with residual control into the second season. The drill proved more effective than the broadcaster for the application of the DDT/superphosphate dusts. Applications of DDT with inert diluents by power dusting machine were equal in effect to the drill applications in superphosphate. Winter treatments by broadcaster with 8 oz. DDT per acre gave a good initial kill, but the residual effect was limited. Summer applications of DDT by means of the low-volume boom spray were inferior to the dusting methods. Aerial application of DDT spray during the winter months gave very good results.

The main factors operating against a more effective control in the field treatments appear to be loss of DDT in wind drift, unevenness of distribution, and the burial of DDT beneath the soil surface by the trampling of stock.

57/73 SWAZILAND IRRIGATION SCHEME, 1956/57. INSECT PESTS OF RICE.

K. S. McKINLAY. Colonial Pesticides Research Unit, Arusha, Tanganyika. Misc. Report No. 188.

The insect pests of rice considered of sufficient importance to justify further experimental work are:

(i) The leaf eating beetle, *Trichispa sericea*
(ii) The stem borer, *Ampycodes pallidicosta*
(iii) An unidentified species of Diopsid Dipterous stem borer.

The results of an experiment in the control of *Trichispa* are tabulated below. The various treatments were all applied in 12 galls. of water per acre.

TABLE 1

Percentage Mortality of *Trichispa* Larvae After a Single Insecticide Application

Treatment	Cost/acre	Mortality 19 hours	Mortality 64 hours
Dieldrin $\frac{1}{4}$ lb.	Sh. 7/9	0%	21%
Dieldrin 1 lb.	Sh. 31/0	10%	72%
Endrin $\frac{1}{4}$ lb.	Sh. 10/7$\frac{1}{2}$	5%	56%
Malathion 1 lb.	Sh. 14/0	61%	69%
Dipterex 1 lb.	....	13%	73%
Untreated	....	2%	0%

Indications from this trial are that malathion at 1 lb. actual per acre would give the most rapid and effective control at a reasonable price.

The principal rice insecticides trial was planted on 6.10.56. Germination, and consequently stand, were poor and uneven. During the growth of the crop weeds were numerous and often allowed to reach a considerable size before they were removed. During the course of the experiment the following treatments were applied in 6 gallons of water per acre.

Treatment A. Endrin $\frac{1}{4}$ lb. actual per acre.
" B. Dieldrin $\frac{1}{4}$ lb. actual per acre.
" C. DDT 1 lb. actual per acre.
" D. Toxaphene 2 lb. active per acre.
" E. Dipterex 2 lb. active per acre.
" F. Malathion $\frac{1}{4}$ lb. active per acre.
" G. Malathion 1 lb. active per acre.
" H. Iso-chlorthion $\frac{1}{4}$ lb. active per acre.
" I. Iso-chlorthion 1 lb. active per acre.
" J. Untreated control.

Since there was so little previous information on the rice pests it was not possible to lay down a spray programme in advance and applications had to be made when any particular pest seemed to be present in sufficient numbers to justify treatment.

Treatments were applied on 16/11/56 and 26/11/56. Three counts of the number of "Dead Hearts" were made between 30/11/56 and 13/12/56, and the totals are tabulated below.

TABLE 2

Total Numbers of "Dead Hearts" due to Diopsid Stem Borer

A	B	C	D	E	F	G	H	I	J
40	19	74	41	22	46	27	21	18	108

Treatment against *Trichipsa* adults was applied on 21/12/56 and 31/12/56, and the results are shown below. Damage was confined to the adults' feeding; no eggs had been laid.

TABLE 3

Percentage of Plants Damaged by Adult *Trichispa*

A	B	C	D	E	F	G	H	I	J
13	34	37	25	25	12	14	52	19	34

Examination of 1000 stems on 22/1/57 showed that 5% contained living larvae of Ampycodes. Insecticide was applied on 23 and 29/1/57 and 8/2/57. (Endrin at ½ lb/acre was substituted for Dipterex in Treatment E).

TABLE 4

Mean Percentage of Stems Infested with Ampycodes between 22.1.57 and 21.2.57

A	B	C	D	E	F	G	H	I	J
10	22	33	27	32	22	22	35	17	31

Least significant difference, 5 per cent level, 9.0

TABLE 5

Mean Number of "White Heads" per 1/10th Acre Plot on 21.2.57

A	B	C	D	E	F	G	H	I	J
4.0	10.0	22.4	25.6	17.4	15.0	13.6	19.0	8.4	24.0

Least significant difference, 5 per cent level, 9.3

Comparison of the mean yield from each treatment with the Ampycodes infestation showed there was a highly significant negative correlation. The best correlation is obtained by taking into account the whole infestation throughout the period of the attack, but the results also indicate that the greater part of the loss of yield was due to the larvae which attacked the plants early in the infestation. There seems little doubt that Ampycodes can cause heavy loss of yield.

Trichispa sericea adults and larvae can cause heavy damage on the rice leaves but it is difficult to assess the effect of this damage, if any, on yield. The leaf damage will certainly set back the growth of the rice.

Diopsid stem borer occurs only in very small numbers at present but should be watched carefully for a slight change in habits could convert it into a serious pest. Malathion at 1 lb. actual per acre is suggested provisionally as the best control for Trichispa and Diopsid borer.

Ampycodes pallidicosta is the most serious pest of rice on the Swaziland Irrigation Scheme and the indications are that it can cause very considerable losses of yield. Insecticide trials showed that endrin was an effective insecticide for its control but further work is necessary to find the optimum number and timing of insecticide applications.

Towards the end of the summer an increasing proportion of Ampycodes larvae go into diapause and overwinter as resting larvae in the rice stubble. Here they are very well protected and extremely difficult to kill with insecticides, flooding or burning. Since up to 60% of the rice stems may contain Ampycodes the carry over in a ratoon crop can be considerable. Further entomological work on this question is essential.

57/74 REPORT ON INVESTIGATION OF PADDY BUG IN BRITISH GUIANA

C. R. WALLACE. Colonial Office. Jan. 1957.

This investigation took place during the period 6th July 1952 - 6th February 1954, and covered three rice seasons, viz. autumn crops 1952 and 1953, and spring crop 1953. Throughout these 3 seasons there was no crop, or section of a crop seen, that showed that the yield of paddy had been reduced by paddy bug (Solubea poecila Dallas). A great part of each rice season was consumed in searching for sufficiently heavy and extensive field infestations on which to test control measures.

Two major sources of loss in the rice industry in Guiana are the production of "wind rice" and discoloured rice grains. "Wind rice" is rice in which the grain fails to form in the paddy heads. It may be due to sterility in the plant, or attack by such insects as lepidopterous stem borers

Diatraea saccharalis F. and *Rupela* (*Scircophaga*) *albinella* (white stem borer), both of which can cause severe damage. Discoloured grains, the presence of which leads to downgrading in the market value of the rice, fall into 3 main classes: "Jack grain" in which the kernels are yellow to light yellowish-brown, is caused by storage for too long a period at high moisture content; "Red Rice", where the colour ranges from pink to very dark red, is found in crops of low varieted purity; and "Ghandi grains", the staining of which is darker than "Jack grain" and may be black. Losses due to both "wind rice" and "Ghandi grains" have been attributed to paddy bug attack, though hitherto without the support of adequate experimental evidence.

Because of the doubt regarding the responsibility of paddy bug for the damage attributed to it, experiments to determine this were instituted in which paddy bugs were confined in large cages placed round rice stools.

Experiment I was in 5 randomised blocks; each block comprised 4 plots each of 1 square yard as follows:

Control:	4 stools of rice caged together; no paddy bugs added
Infested I:	4 stools of rice caged together; 60 paddy bugs added
Infested II:	4 stools of rice caged together; 120 paddy bugs added
Uncaged:	4 adjacent stools of rice selected at random in the vicinity of each block on the day of harvest.

The crop from the plots was reaped approximately 15 days after the start of the experiment, sun dried and hand stripped (but not winnowed). It was later passed through a grain-sorting machine (Carter Dockage Tester) which separated, by aspiration, the grain fraction from the light chaffy material (in this case little different from pure "wind rice").

Results are summarised below:

Weights of the Various Fractions (Treatment Totals in Grammes)

	Uncaged	Control	Infested I	Infested II	Total
Aspirated material	$119\frac{3}{4}$	$125\frac{1}{2}$	$133\frac{1}{2}$	140	$518\frac{3}{4}$
Light, unusable grains	$118\frac{1}{2}$	$107\frac{3}{4}$	149	185	$560\frac{1}{4}$
Usable paddy	1417	$1258\frac{1}{4}$	$1139\frac{1}{2}$	1155	$4969\frac{3}{4}$

The usable paddy was processed by a laboratory method which for small samples gives results comparable to full scale milling practice. The samples from each lot were compared visually for the incidence of "Ghandi grains". The "Infested II" sample was found to contain the highest proportion of discoloured grains and there was a distinct contrast comparing the two "infested" samples against the "control" and "uncaged" samples.

It is concluded that plants subjected to heavy paddy bug infestation in the 15 to 16 days preceding harvest produced a significantly greater proportion of light grain than did plants which had little or no infestation during that period. In heavily infested plants the proportion of aspirated material was slightly higher and the yield of usable paddy somewhat lower than in the controls, but these differences were without statistical significance: this indicates that S.poecila inflicts no great loss of yield upon paddy in its last two weeks of maturation.

The prepared rice obtained from paddy in the three caged treatments showed an obvious correlation between intensity of infestation and the frequency of the darkly discoloured grains which cause a sample to be classed as "Ghandi rice". It appeared certain that attack by paddy bugs is either a direct cause of the dark stainings, or a leading factor in their production.

To determine whether there was any correlation between paddy bug attack and wind rice a second experiment using 96 plants to compare 4 different treatments in a design of

24 randomised blocks was set out. Each plot was represented by one caged panicle in a relatively early stage of development, and each caged panicle was in a separate stool of rice.

Treatments were:

A. Control: no bugs

B. Two adult bugs per panicle

C. Four adult bugs per panicle

D. Eight adult bugs per panicle

The number of adult bugs per cage was maintained at a constant level.

An additional 96 stems with panicles in the same stage of development were labelled, but left uncaged, to determine any possible ill-effects which caging might induce.

The experiment ran from March 25th to April 14th. The results, after the elimination of stems which suffered damage from pests other than S. poecila (e.g. stem borer), are summarised below.

Wind Rice and other Fractions in the Yield of 75 Caged Panicles

Treatment	No. of panicles	Total No. of spikelets	Spikelets in each Category (as percentage of the treatment total)		
			wind rice	intermediate	Good grains
A	17	1057	9.95	11.35	78.70
B	19	1932	51.86	22.98	25.16
C	18	1764	87.19	8.96	3.85
D	21	1797	94.05	5.51	0.45

For comparison the yields given by 21 of the uncaged panicles previously referred to, and chosen at random, were:

Wind Rice and other Fractions in the Yield of 21 Uncaged Panicles

No. of panicles	Total No. of spikelets	Spikelets in each Category (as percentage of total in and column)			
		wind rice	intermediate	good grains	other damage
21	1658	9.71	16.34	72.49	1.45

These findings offer experimental proof that S. poecila can cause excessive "wind rice" and a lessened yield of grain.

Due to the low rate of infestation no adequate field experiments on insecticide control were possible. It was shown however, that the insect was unable to withstand either of the two dusts, Agrocide 7 (2.6% gamma BHC) and Pybuthrin C (0.2% pyrethrins + 2% piperonyl butoxide). Application rates of 20-30 lb per acre would almost certainly be ample, and it is quite probable that 15 lb/acre would suffice.

Conclusions

For the control of S. poecila by insecticides spraying except from aircraft can be dismissed. Fogging is probably the ideal method of insecticidal control under local conditions but the choice of suitable insecticides and fog generators requires further investigation. In the meantime drift dusting with certain preparations is recommended as a means of halting the attack upon the crop and reducing the current infestation to negligible proportions. No treatment is likely to provide more than a few days' protection against reinfestation, but the need for such protection may seldom arise.

57/75 THE DEVELOPMENT, CONSTRUCTION AND TESTING OF THE S.A. 6 INSTALLATION FITTED IN THE "DRAGONFLY" HELICOPTER FOR THE DISPERSION OF INSECTICIDES

R. F. HILL and R. B. E. STUBBS. Ministry of Supply, Chemical Defence Experimental Establishment Portion, Technical Paper No. 605.

A pump operated spray installation, incorporating a spray boom and nozzles and designated the S.A. 6 Spray Installation has been developed and tested. This installation, which operates at a constant rate of flow up to a maximum nominal throughput of 10 gal/min., has been fitted to a "Dragonfly" helicopter.

The spray boom is mounted below the fuselage, just aft of the beginning of the tail boom, and approximately on a horizontal level with the bottom of the cabin door.

The results of performance tests have indicated that the installation functions satisfactorily, that the spray boom (at least up to forward speeds of 30 knots) is within the disturbed zone of air created by the rotor blades and that negligible contamination of the aircraft occurs within the cruising speed range of the helicopter.

57/76 DESIGN, DEVELOPMENT AND TESTING OF AN INSECTICIDE COMPRESSION SPRAYER OF THE CONSTANT PRESSURE TYPE

E. H. ADAMS and R. B. E. STUBBS. Ministry of Supply,
Chemical Defence Experimental Establishment Porton,
Technical Paper No. 594.

A modification to the Sprayer, Compression, Insecticide, Mk.1 is described. This incorporates a specially designed pressure regulating valve, weighing only $5\frac{1}{2}$ ozs. and accurate to ± 1 lb/sq. in. which is located between the air reservoir and the liquid container. Formulations of both the oil solution type and the water wettable powder type can be dispersed at a uniform pressure irrespective of the quantity of liquid discharged from the tank.

57/77 ROTARY ATOMISERS

R. T. JARMAN. Colonial Pesticides Research Unit, Porton.
Repórt No. 127. June 1957.

This paper is mainly concerned with a consideration of equations correlating various factors governing the v.m.d. (volume mean diameter) of droplets produced by three types of rotary atomiser - i) the rotary brush, ii) the spinning disc, iii) the spinning cage. The method of droplet formation is also discussed.

Performance figures for 4 types of rotary atomiser are given. Assessment was made spraying the following liquids, dyed with 1% Waxoline Red:-

(i) T.P. 5007, which is a 10 per cent solution of DDT in a mixture of 1 part of fuel oil and 4 parts of power kerosene.

(ii) A DNC solution consisting of 20 per cent Dinitro-ortho-cresol, 72 per cent Iranolin Kerosene Extract Bottoms and 8 per cent Iranolin 2241.

(iii) Kerosene (burning oil).

The head of the rotary brush consisting of a number of wires radiating from a hub, somewhat resembles a chimney sweeping brush, while the rotating disc consists simply of a number of discs mounted coaxially. The rotating cage is the name given to a rotating cylinder of wire gauzes, in which the insecticide is fed from the axis of the cylinder.

The rotary brush was installed under the fuselage of an Avro XIX: the cage atomisers were mounted one on each lower wing tip of a D.H. Tiger Moth: and the multiple rotating disc atomisers were suspended from near the tip of each wing of an Auster J.I.B. Performance figures for the Microsol 202 are also included.

TABLE I

Performance of the Atomisers

Atomiser	Rotary Brush	Aircraft Discs	Spinning Cage	Microsol 202
Rotation speed (r.p.m.)	2,500	4,000	15,000	16,000
Diam. (cm)	25.4	26.7	10.2	13.5
Liquid used	T.P. 5007	D.N.C.	T.P. 5007	Kerosene
Airspeed (m.p.h.)	120	70	75	-
Emission Rate (gals/min)	12 : 7	11	6	0.04 : 0.09
(c.c/sec)	910 : 530	840	460	3 : 7
v.m.d. (microns)	120 : 90	110	50	30 : 46
Range (microns)	60 : 50	100	30	20 : 32

The author concludes as follows:

(a) Very uniform sprays have only, as yet, been obtained in the laboratory with very small emission rates.

(b) The low emission rate used, rather than the rotary atomisation process, as such, has been necessary in producing very uniform sprays.

(c) Air blast atomisation was important in all the sprayers tested.

(d) It was found that while the v.m.d. could be reduced slightly by decreasing the emission rate, it was to a first approximation independent of the emission rate, and given approximately by a simple equation:-

$$\text{v.m.d.} \simeq \frac{K}{W}\sqrt{\frac{\gamma}{D\rho}}$$

where,
D = diameter of disc
W = angular velocity of disc
γ = surface tension of liquid used
ρ = density of liquid used
K = a value probably a constant for the apparatus used

57/78 THE EVAPORATION OF SPRAYS

R. T. JARMAN. Colonial Pesticides Research Unit, Porton. Report No. 145.

Measurement of the evaporation rate in the atmosphere of a dyed kerosene spray gave results which compare favourably with theoretical values deducible from Rosin-Rammler, Probert, Langmuir and Jarman mathematical treatment.

In field experiments, spray was emitted for 30 seconds at 10 gallons per minute, as a line source, from an Auster J.5G flown straight and level at 40 ft. across wind. Droplets, deposited on filter papers laid in a downwind line at 10 yard intervals, were assessed visually and colorimetrically.

57/79 DEPOSITION OF DROPLETS

I. - THE RELATIVE IMPORTANCE OF SEDIMENTATION AND INERTIA PROCESSES

R. T. JARMAN. Colonial Pesticides Research Unit, Porton.

II. - THE COLLECTION EFFICIENCY OF THE CASCADE IMPACTOR AND ISOLATED SPHERES
R. T. JARMAN and J. W. KING. Colonial Pesticides Research Unit, Porton. Report No. 119.

III. - DEPOSITS ON HORIZONTAL SURFACES IN AN AIRSTREAM
R. T. JARMAN. Colonial Pesticides Research Unit, Porton. Report No. 123.

IV. - THE COLLECTION EFFICIENCY OF GAUZES
R. T. JARMAN. Colonial Pesticides Research Unit, Porton. Report No. 144.

In the first paper the relative importance of the inertia and sedimentation processes (for circular cylinders in a wind tunnel) is considered. That of inertia is shown to increase as the droplet sizes become larger.

The second paper relates to collection efficiencies of spheres and a cascade impactor, exposed in wind tunnel to a fairly uniform aerosol, in terms of the relation

$$E = \frac{100 \quad Q}{A.c.v.t.}$$

where

E = collection efficiency.

Q = volume of droplets deposited.

A = cross sectional area of object in plane normal to airstream.

c = concentration of droplets, in volume of droplets per unit volume of air.

v = velocity of airstream, or wind speed.

t = time object is exposed to aerosol.

Collection efficiencies for spheres of diam. 1.27 or 2.54 cm. are of the order of 85%, for droplet diameter of 100 µ at wind speeds of 3 metres/sec. Values are stated to be similar to those computed by Langmuir and Blodgett for ideal fluid conditions where inertia only caused deposition.

The efficiency of the cascade impactor to droplets with diameters ranging from 50 - 160μ (wind speed 3-5 metres/sec.) is shown to be 70 ± 10%.

Part III contains details of an investigation into the relative deposits formed on flat surfaces such as glass plates, uncoated or coated with magnesium oxide or silicone, filter papers and jump cards (1) when exposed to a fairly homogeneous spray in the wind tunnel or in field trials.

The liquid sprayed in laboratory tests was kerosene extract (bottoms) containing phenyl-α-naphthylamine which, to facilitate colorimetric measurement, was "developed" with diazotised sulphanilic acid yielding a purple dye. In field experiments, TP 5007 (2) was sprayed from boom and nozzle spraying equipment fitted to an Auster fixed wing aircraft or a Westland Dragonfly helicopter. Comparison of assessment obtained during an Auster trial using magnesium oxide and siliconed plates is reproduced at the foot of this abstract.

The collection efficiency of a horizontal siliconed plate, measured according to the methods and apparatus described in Pt. II, was found to be 50% to droplets of 70 microns diameter in a 3 m/sec. wind thereby indicating that forces other than gravity are involved when particles deposit on horizontal surfaces in an airstream. It is concluded that bouncing and shattering of droplets on impact can lead to measurable differences in assessing droplet sizes and that coated surfaces appear non-ideal for sampling.

In part IV studies are reported on the collection efficiency of wire gauzes. The latter provide a straightforward method for sampling small droplets drifting in an air stream.

The relation between deposit and aerosol concentration has been established for varying droplet sizes and closeness of wires, by direct measurement in a wind tunnel, and found to compare favourably with that predicted theoretically.

It is concluded that the collection efficiency can be computed with confidence from graphs and formulae.

Description and figure of the wind tunnel are contained in papers II, III, and IV.

Notes

(a) Jump cards: Porton term for sheets of cardboard 18" x 18" x $\frac{1}{8}$" faced with filter paper.

(b) TP 5007: 4:1 mixture of power kerosene and fuel oil, containing 10% DDT.

Comparison of Assessments

Plates	MgO	Siliconed
Volume median diameter (microns)	150	220
Range (microns)	130	100
Volume diameters		
25% 75% (microns)	100 230	170 270
Ground deposit (% of emission)	20	95

REVIEW ARTICLE

PROTECTION AND PRESERVATION OF TIMBER

D. J. COLWILL and B. HYDE-WYATT. Colonial Pesticides Information Service. September, 1957.

This article surveys present day techniques for defending timber, during and after growth, against pest attack.

Losses Caused by Pests

Some indication of the timber lost through damage by forest pests is contained in the Timber Resource Review of the U.S. Forest Service. In 1952 total timber production (U.S.A.) was 48.8 billion board feet; timber loss caused by pests was 31.3 billion board feet or some 64% of production. (Of this total loss 7.5 billion board feet represents killed trees and 23.8 billion board feet represents loss of growth due to pests.

Timber Consumption in the United Kingdom

Vast amounts of timber are used annually throughout the world. U.K. requirements[28] during 1955 and 1956 are shown in Table 1. Home grown timbers provide about one third the volume of hardwood and a much smaller fraction of softwood. Hardwood species, mainly used for specialty purposes, include oak (*Quercus robur*, *Q.petraea*) beech (*Fagus sylvatica*), ash (*Fraxinus excelsior*), sycamore (*Acer pseudoplatanus*) and birch (*Betula pubescens*, *B.berrucosa*). Home grown softwoods include Scots pine (*Pinus sylvestris*), Norway spruce (European Whitewood = *Picea abies*), European larch (*Larix decidua*), Sitka spruce (*Picea sitchensis*) and Douglas fir (*Pseudotsuga taxifolia*).

Principal softwoods imported include spruce (*Picea* spp.), Western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga taxifolia*) and Western Red Cedar (*Thuja plicata*) from Canada; European Redwood (Red deal = *Pinus sylvestris*), European spruce (White deal = *Picea abies*) and European fir (*Abies alba*) from Sweden, Finland and USSR, with lesser amounts from Norway, Poland and Czechoslovakia. Shipments are received of Parana pine (*Araucaria augustifolia*) from Brazil, of Maritime pine (*Pinus pinasta*) from France and *Podocarpus spp.* from E.Africa. Supplies from the U.S.A. consist of species occurring in Canada together with Southern yellow pine (*Pinus palustris*), *P.taeda* and *P.echinata*, Californian redwood (*Sequoia sempervirens*) and occasionally *Taxodium distichum*. Among odd shipments are *Pinus koraiensis* and other species from China; Himalaya blue pine (*Pinus wallichiana*) and *Cedrus deodara* from India and Pakistan; *Podocarpus*, *Agathis* and *Dacrydium* from the Fiji Islands; and Slash pine (*Pinus caribaea*) from British Honduras and some of the W. Indian Islands.

Principal hardwoods include beech from France and Yugoslavia, oak from Japan, keruing (*Dipterocarpus* spp.) from Malaya, and obeche (*Triplochiton scleroxylan*), okume (*Aucoumea klaineana*) and abura (*Mitragyna ciliata*) from W. Africa. Some teak (*Tectona grandis*) though substantially less than before the war, is received from Burma, also small quantities of *Eucalyptus* spp. (Australia), greenheart (*Ocotea rodiaei*) from British Guiana and other species from British East Africa. (see Appendix I).

It is noteworthy that imports of tropical timbers by O.E.E.C. countries, which barely exceeded 100 million dollars in 1953, were estimated to be worth 157 million dollars in 1955. (85% were from Overseas territories of member countries).26)

TABLE I

Timber	Millions of Cubic Feet (Approx.)					
	Imported		Home Grown		Total	
	1955	1956	1955	1956	1955	1956
Softwood	255.3	241.2	8.3	7.3	263.6	248.5
Hardwood	43.3	40.7	23.5	20.9	66.8	61.6
Pitwood	-	-	-	-	1.32	-
Plywood	-	-	-	-	14.5	13.4

(Based on figures supplied by the Board of Trade).

Some Notes on Timber 2), 3), 52), 76).

Timber, a very serviceable and valuable commodity, comprises many species growing under diverse environmental conditions. The suitability of a particular wood for a given purpose is governed by such factors as its seasoning, bending and mechanical properties, its natural durability, its ability to absorb preservative, and its working qualities.

Certain species of rapid growth (aspen (Populus tremula), fir, spruce, hemlock) are extensively used in the preparation of wood pulp for paper manufacture. Some with a high natural resistance to decay, Scots pine (Baltic Redwood), Greenheart or Pitch pine (Pinus spp.) are ideal for marine, transport and telecommunication purposes. Many others fulfil a variety of needs in building, furniture making, packaging and panelling.

Timbers are classed as hard or soft woods. Hardwoods are obtained from deciduous or evergreen dicotyledenous species; conifers yield the softwoods. It is an arbitrary distinction since the softest and lightest woods (e.g. Balsa) are, by definition hardwoods.

I. Types of Attack

Timber is subject to attack by three main types of organisms:- insects, fungi and marine borers. In some cases damage is caused by mammals, mainly rodents and deer, by debarking and defoliating.

1. Insect Attack57)

Insects attack timber in all stages from seed to finished product, and constitute the most important pests. The principal types of attack are timber boring and defoliation. Most timber insect pests belong to the orders Coleoptera (Beetles), Lepidoptera (Moths and Butterflies), Isoptera (Termites), Phasmida (Stick Insects), Hymenoptera (Wood Boring Wasps, Sawflies and Ants), Orthoptera (Locusts and Grasshoppers) and Hemiptera (Plant Bugs, Aphids, Scale Insects.)

Phasmids, lepidopterous larvae, and sawfly larvae are the main defoliators attacking trees, the first being limited in distribution to the warmer climates only. Locust swarms, in the areas where they occur, can cause serious damage to growing timber, but they are a general pest of all crops and their control falls outside the scope of this review. Grasshoppers are not an important timber pest, and respond to the same treatment as other defoliators. Sawfly larvae, for example the Larch sawfly (Pristiphora erichsoni (Htg)) of North America, are important in temperate areas and cause considerable damage to conifers. Leaf-cutting ants of the genus Atta are locally destructive in parts of tropical America and the West Indies. Defoliators damage by causing malformations, irregular growth, and stunting, and in the cases of repeated and intensive attack, by killing the tree.

Termites are known principally for the damage they cause to structural timber and such articles as furniture, books, and the like, but they will also attack young healthy trees, inhibiting their growth or killing them.

At all stages of development, timber is susceptible to attack by Coleoptera. The principal damage is caused by the boring of larvae, adults, or both. Growing trees are attacked by many species of Cerambycidae (Longhorn beetles), while other species of the same family attack freshly felled, or stored timber.132) This family is most abundant in the tropics, but certain species are major pests in temperate regions, for example Hylotrupes bajalus L., the House longhorn which attacks seasoned softwoods in Europe.15) The Ambrosia beetles - members of the families Scoltylidae and Platypodidae - not only bore into timber, but introduce a black staining "Ambrosia fungus".22),35) They are most abundant in tropical forests and constitute major pests of hardwoods.124) The annual loss caused by them in Ghana alone exceeds £1,000,000. Attack first occurs within 24 hours of felling and continues thereafter until the moisture content of the wood falls below the level necessary for Ambrosia beetle survival. Bark beetles (Scolytidae and Platypodidae) tunnel beneath the bark and in the surface layers of the wood. The physical damage they cause is not usually extensive, but they are frequently vectors of fungal disease which causes the death of the tree. In the U.S.A. the Smaller European bark beetle (Scolytus multistriatus) is the vector of Dutch elm disease and elm phloem necrosis which are annually responsible for the loss of a large number of elms. It has been demonstrated in the laboratory that the bark beetle Pseudopityophthorus minutissimus (Zimm) is capable of transmitting the Oak-wilt fungus Endoconidiophora fagacearum.70)

Seasoned timber is susceptible to attack by a number of different groups of beetles, including the Powder-post beetles (Lyctidae and Bostrychidae), the Death-watch beetle (Xestobium rufovillosum) and the Furniture beetle (Anobium punctatum).

A number of aphids, scale insects, and frog hoppers (Hemiptera, sub-order Homoptera), are important pests of timber. In New Zealand Rhophalosiphum abietinum Walk, an aphid pest of spruce, sometimes causes defoliation. The Pine tortoise scale in Canada can kill considerable areas of Jack pine,86) Damage is usually caused by the homopterous sap suckling feeding habit, but some species are believed to be vectors of disease, or to render their host more liable to fungus attack. Myzocallis annulata Htg. is an aphid infesting oak in Tasmania, and when it is present in abundance the scaly mould fungus which develops on its excreta retards the growth of the tree.

Bongberg43) gives a comprehensive review of the most important insects insects causing damage to forests in the U.S.A. during 1956. The 1956 Annual Report of the Forest Insect and Diseases Survey119) covers the incidence of pests in Canada.

2. Fungal Attack

Economically the most important fungi attacking growing trees are the heart rots, and butt rots, for example *Fomes annosus*. It has been estimated that this fungus, in a sample plot of spruce, was responsible for an average loss of approximately 23% in the value of the crop. It causes roughly 90% of the decay of conifers in Great Britain. The extent and severity of attack on spruce was found to increase with increased severity of thinning. The stumps are infected by spores, presumably air borne, and the fungus passes from the stump roots through root connections to adjacent healthy trees.31)

Other important genera of fungus attacking living trees are *Poria*, the white ring rot in Canada, *Polyporus* and *Armillaria*. Biraghi41) notes some of the diseases of conifers in Italy. Recent literature on fungal attack is listed by the U.S. Department of Agriculture.23)

In addition to fungi which cause rotting of the wood, felled timber is subject to attack by sapstain fungi. These cause a discolouration of the sapwood, generally blue or grey in colour, which reduces its commercial value. In one or two cases however, sapstain produces a decorative effect which enhances the value of the wood for certain ornamental uses (Levy, personal communication.) The mechanical strength of sapstain-attacked timber is not appreciably affected, but it is rendered more liable to attack by rot fungi. Rogister99) gives a comprehensive account of blueing of poplar by *Botryodiplodia theobromae* and reviews the literature on the fungi responsible for blue stain.

A number of beetles are vectors of fungus, the most important being the Ambrosia beetles which introduce the black discolouring Ambrosia fungus into their tunnels. The Elm bark beetles (Scolytus *scolytes* and *S.multistriatus*) cultivate *Ophiostoma ulmi* which causes the death of the Elm. Other species of *Ophiostoma* are reared by the Bark beetles of conifers and cause a blue rot of the standing and felled tree trunks66).

In use, timber is subject to attack by many different fungi. In buildings the most destructive is Dry Rot, *Merulius lacrymans*. *Coniophora cerebella* (cellar fungus) and species of *Poria* are also important, the latter particularly in mines. Out of doors Lentinus lepidus is very destructive. The brown, crumbling rots, do not attack the lignin in the wood, but the white rot fungi are able to decompose lignin, and in time can completely destroy a piece of timber.

In certain situations, notably the wooden slats in water cooling towers, and also in thin materials like plywoods where the surface to volume ratio is high, soft rot, which is caused by the attack of cellulose-destroying micro-fungi including Chaetormicin spp., Stysanas sp. and Oribicula sp. is of considerable economic importance. Coniferous woods are more readily attacked than hardwoods. The importance of soft rot in the decomposition of wood is covered by Savory. 105),106)

Findlay62) gives an up to date survey of timber decay; he also133) deals with the physiology of wood-destroying fungi. Becker38) refers to the main fungal and insect pests of wood in Germany.

3. Marine Borer Attack13),98)

Timber is attacked by certain species of two groups of marine animal, the molluscs and the crustacea. The molluscan borers include Teredo (the Ship worm), Bankia, Xylophaga and Martesia; the crustacea, Limnoria (the Gribble), Sphaeroma and Chelura.

The various species of Teredo are the most important and destructive of the molluscan borers. In the 1930's the damage in one year at Lynn Harbour, Massachusetts, was assessed at $1,000,000. The speed and extent of attack is remarkable; within 3 years of the spread of Teredo to Plymouth, Massachusetts, every wharf was destroyed. Shipworms are most common in tropical waters, but some species occur in temperate seas, while Teredo norvegica is found as far north as the Arctic waters of the U.S.S.R.

The adult has a worm-like appearance, and may grow to a length of several feet. Their burrows often completely riddle a piece of timber. The only external opening to the gallery is very small ($<$ 0.5 mm), and this can be closed by two small plates (pallets) at the hind end of the animal. There is, therefore, little or no external sign of damage.

Limnoria burrows parallel and close to the surface. The tunnel is short (about 1 inch) but the young push out new burrows on either side of it. In a short time the surface of the wood becomes weak and rotten, and is rapidly worn away. Limnoria damage can be as rapid and severe as that due to Terodo, but the presence of the pest is easily detected.

In nature *Chelura* frequently occurs with, and under laboratory conditions cannot survive in the absence of *Limnoria*. Some authorities consider that the damage it causes is limited to the enlargement of gribble burrows.

4. Mammalian Attack

Seedlings and young trees can suffer severe losses due to attack by ungulates and rodents. Deer attack bark, young shoots, and foliage, whilst rodents will ringbark the tree. Rabbits annually eat large numbers of seedlings.131)

II. Control Methods Employed in Forest Husbandry

There are few methods of affording protection to growing forest timber that are both practicable and economic. Pest control is generally worth while only against large scale attacks in which extensive damage is probable. Forest areas are, in general, difficult of access, and the most satisfactory means of applying an insecticidal treatment is by aerial spraying or dusting, the former method of application being currently preferred. Fungus control in forest areas is not at present possible.

In North America extensive aerial insecticide treatments are used against forest defoliators including the Gypsy moth (*Porthetria dispar*), the Spruce budworm (*Choristoneura fumiferana*) and the Tussock moth (*Hemerocampa pseudotsuga*).117) Despite original opposition from various wildlife protection organisations and similar bodies with no interests in timber, spray campaigns are now a regular feature of the United States forest protection campaigns in many States. DDT at a rate of $\frac{1}{2}$ - 1 lb. per acre is commonly used, applied either by light aircraft, e.g. Stearman biplanes fitted with a 400 or 450 h.p. engine, capable of carrying 100-120 gallons of solution containing 1 lb. DDT per gallon, and operating from temporary airstrips, or larger machines (D.C.-3, B.-18), carrying 800 gallons and operating, sometimes at a considerable distance, from permanent airfields. Sprays having a droplet mass median diameter of 150 are favoured.55),64),72) The insecticide acts both as a contact and a stomach poison. Larval kills of over 90% have been reported, and loss of foliage is considerably reduced.37) Methoxychlor can be used instead of DDT when a small wood surrounded by pasture is to be sprayed, since it is supposedly not secreted by cows in their milk. Against Gypsy moth 0.05% parathion, 0.5% endrin and 1% DDT sprays have been found effective.92) In Australia control of the Phasmid *Didymuria violesciens*, which was responsible for defoliation damage in state forests on water catchment areas in

New South Wales, was achieved by aerial application of dieldrin at 0.8 lb/acre: 4 ozs/acre should, and 2 ozs/acre may prove effective. (Winfield, personal communication.)[29].

Endrin is proving effective against many defoliators. In South Africa it has given excellent control of the Wattle bagworm (*Acanthopsyche junodi* Heyl.)[93] when applied by air, two ounces of endrin and half a pint of Alboleum in three gallons of water per acre gave 95.3% control, results assessed after 16 days.[94] Other defoliators reported to be controlled include *Malacosma* (Lackey moth), *Porthetria dispar* (Gypsy moth), *Euproctis chrysorrhoea* (Brown-tail moth), *Tortrix* (Leaf-roller moth), and *Thaumetopoea* (Processionary caterpillars.)[4], [54] Protection against leaf-cutting ants of the genus *Atta* is afforded to young trees by a 2% suspension of chlordane sprayed twice a year on the trunks and the surrounding soil.[58] The use of dieldrin in the soil reduced the mortality rate of *Eucalyptus* due to termite attack from 15% to 2%, *Crematogaster* ants were also killed. With aerial spraying the crawler stage of the Pine Tortoise scale (*Torimeyella numismaticum* (P. & M.)) is most economically controlled by a malathion emulsion.[86]

Many important forest pests, including the Gypsy moth in North America, probably the Larch sawfly in Canada, and others, are not naturally indigenous to the areas in which they cause damage, but have, at some time, been imported. In the absence of their natural controlling agents they are free to breed abnormally large populations and cause damage of considerable economic importance. In many countries legislation has been enacted to prevent the introduction of potentially noxious pests.

One way of combating a pest species occuring in an area to which it is not indigenous is by means of the introduction of natural predators and/or parasites. If such a parasite or predator can become established it will often bring the pest population under control and considerably reduce the damage caused. Bacterial and virus diseases have been successfully introduced to control pest populations. Diseases of this sort can, in some cases, be prepared in a culture form that enables them to be spread by means of sprays, etc.[65] Hughes[8] has prepared an annotated list of insects reported to have virus diseases. Franz[35] briefly reviews the micro-biological control agents of the sawfly *Neodiprion sertifer* (Geoffr.) The parasites and pests of the Larch sawfly are covered in papers by Muldrew, Buckner and Heimpel[118]; Raizenne[97] lists the forest sawflies of Southern Ontario, together with their parasites.

Biological control methods have the great advantage over chemical control methods in that once the organism is established it reproduces itself and provides a perpetual control which, unlike chemical applications, does not require periodic repetition. A biological control agent will not normally eradicate a pest, and in some cases it can be regarded only as a means of reinforcing a programme of chemical control. The population fluctuation of a parasite or predator usually lags behind that of its host, especially in species which have only one generation per year, and rapid control of large outbreaks is not effected. On the other hand the spread of bacterial and virus diseases is more rapid in large populations which are subject to crowding, and in the field of applied biological control their use promises to be of great value. The employment of biological control applied to the control of forest pests is one in which far more work is required at present, but it offers enormous potentialities.

In plantations the control of pests is more simple than it is in virgin forest areas. Areas are more accessible, and a closer supervision can be maintained; pest attacks can be diagnosed at an early stage and preventive measures taken. Treatment of individual trees is possible both against insect and fungus attack.

In the U.S.A. Gibson69) has successfully controlled Douglas fir beetle Dendroctonus pseudotsugae Hopk. with oil based solutions of orthodichlorobenzene, trichlorobenzene, dichloroethyl ether, and ethylene dibromide; emulsions of ethylene dibromide were rather less satisfactory.

Fungal attack is best countered by the removal or treatment of diseases trees, dead stumps, and other possible sources of infection spread. After trees are felled the stumps should be given a protective coat of crude tar or a creosote/tar mixture as soon as possible to prevent infection. Against Fomes annosus (Fr.), trenching, especially on shallow soils, is suggested as a method of preventing its underground spread.

Susceptibility to fungal attack is increased when a tree is physiologically or climatically unsuited to its environment. Species which are properly adapted to the area to be planted should always be chosen when afforestation is being carried out. It is also claimed that an admixture of hardwoods improves the health of conifers, and that such plantations are much less subject to attack than are pure stands. This has also been found true in the case of certain insect pests, mixed stands of white pine and hardwoods being less heavily infested with white-pine weevil (Pissodes strobi (Peck.)) than pure pine plantations.36)

Young trees are particularly susceptible to attack by insects, fungi and also mammals such as deer, rabbits and other small rodents. When they are grown in forest nurseries however, they can be afforded a high degree of protection against most forms of attack. Seed dressings should be used against insects and fungus; combined dressings which give a double protection are available. Control of damping off of *Pinus* sp. is given by captan at 0.2-2%; 2% thiram (2.6 lb. Arasan 75 per 100 lb. seed) also protects against fungi and possibly birds. Protection against insects and also rodents is given by endrin with 1 lb. of 50% concentrate per 100 lb. seed. Aluminium powder at 8-10 oz. per 100 lb. seed affords protection against birds when direct seeding methods of reforestation are used.183)

It has been found that young trees of the genera *Pinus*, *Abies*, *Larix*, *Tsuga* and *Picea* can be protected against Pine weevil *Hylobius abietis* L. when being planted out, by immersing the stems and foliage in a 5% DDT emulsion. Alternatively, after planting or when an attack develops, each tree can be treated with 50 c.c. of 1% DDT spray or 1 oz. of a 10% DDT dust. In experiments dusting treatments generally proved slightly superior to the other methods, whilst spraying and dipping gave closely similar results. The cost of dipping was approximately 15/-d. per acre; that of spraying or dusting was estimated to be of the order of 60/- or 80/- per acre.53)

DDT has been used with good, though not perfect results, for protection of individual Elms against Elm bark beetles (*Scolytus* sp.): it has proved superior to BHC for this purpose. Peace95) recommends a 1.5% solution in miscible oil; concentrations ranging between 1% and 12.5% (on dormant trees) have been employed. The cost of treatment is rather high, and its use is practicable only on trees which are of special value for shade or ornamental purposes. A recent publication of the Canada Department of Agriculture30) deals with Dutch elm disease and the control of its beetle vectors.

During the winters of 1949-50 and 1952-53 German forests suffered losses amounting to several million Deutsche Marks due to damage by rodents, notably the field mole *Microtus agrestis* L. In the state forests of Lower Saxony alone losses amounted to DM.500,000 during the winters of 1951-52 and 1952-53. Protection can be afforded against both rodents and other mammals by the use of repellant coatings applied at the stem bases135) or by mechanically causing the natural production of small amounts of pitch and scar tissue as a deterrent to wildlife.68) These methods, however, cannot be successfully applied on a large scale. Schindler108) reports that field moles can be successfully controlled over extensive areas by poisoning surface growth with dusts of emulsions of toxaphene and endrin.

Myxomatosis proved a most successful controlling agent against rabbits both in Australia and Europe, and the reduction in the populations of the pest was invaluable to forestry. The development and organised spread of more virulent strains of this disease, combined with gassing, poisoning and other control measures, could possibly result in the complete eradication of the rabbit with the consequent elimination of the damage caused by it.

A number of authors including Jahrig[84)] and Mayer-Krapoll[89)] suggest that damage by deer can be minimised by the provision of alternative grazing which should be specially planted and fertilised.

III. Protection of Felled Timber

To protect it from infestation felled timber should be removed from the growing area as soon as possible. The onset of insect attack may be extremely rapid, in the case of Ambrosia beetle within 24 hours and frequently very much sooner. When, as is usually the case, immediate removal is impracticable, some form of temporary protection against both insect and fungus attack should be applied in areas where damage is likely.

Debarking reduces the incidence of Longhorn beetle attack, but increases that of Ambrosia beetle. Stacking logs out of direct contact with the ground will delay termite attack. In areas where this insect is abundant, poisoning of the soil below the stacks with dieldrin is advisable. Where timber is stored, in sawmills, timber yards etc. where termites occur, regular treatment with dieldrin, or soil poisoning with arsenic will give protection. From the U.S.A. it is reported that a 0.3% dieldrin emulsion, applied at the rate of 1 gal/3 cu.ft. has been effective for 7 years.

The entry of boring insects can be reduced by the insecticidal treatment of logs and sawn timber. Becker[39)] found that 0.4% emulsions of gamma-BHC gave complete protection against Ambrosia beetles, Bark weevils (*Pissodes approximatus* Hopk.) Bark beetles (various species of *Scolytidae*) and Longhorn beetles (mainly *Monochamus* sp., and *Asemum moestum* Hald.) Against Ambrosia beetle in West Africa gamma-BHC gave good control at 0.5%, 1 gal/100ft^2 of surface. The effectiveness of aldrin and dieldrin depended on the diluent, carrier, and presence or absence of bark. Arsenic compounds are ineffective in preventing infection.[123)] (See also PANS, (A), *3*, (1), abstract 57/4). Brown[49)] found that in Malaya 3-3.5% gamma-BHC was necessary. BHC formulations have also been found effective in Nigeria for protecting sawn timber,[18)] In the Phillipines the application of dieldrin (12 ozs. of an 18.6% emulsifiable concentrate in 3 gals. water) is stated to have reduced the loss due to Ambrosia beetle from 25% to nil. In Trinidad logs stored in the open and treated with dieldrin suffered no Ambrosia damage after 2 months. (Winfield and Newton: personal communication). On floating logs in West Africa a proprietary brand of Log Grease has been found to give complete protection against water line attack by Ambrosia beetle. (Boocock: personal communication). Ambrosia beetle is no longer able to breed when the moisture content of the log falls below about 40%.

The time of felling influences the degree of fungal attack. Lenzites abietina causes more damage to fir felled between February and October than to that felled during the winter months.66)

Complete immersion in water prevents fungus (and incidentally insect) attack on logs, but does not kill any fungal infection already present. No loss in yield or pulp quality was found in logs stored in this way.

For logs which cannot be stored under water, protection against fungus can be afforded by brushing or spraying with a pentachlorophenol emulsion, or creosote, as soon as possible after felling. If the timber is of a species subject to dote it is advisable to treat the ends of the logs with an antiseptic solution, e.g. 5% sodium pentachlorophenate, before an end coating to prevent drying out is applied. Sapstain can be prevented by dipping converted timber for 15 seconds in a 1-2% bath of sodium pentachlorophenate with a small amount of soda ash or borax added. Ten gallons of this solution treats approximately 1,000 board feet. Sodium ortho phenylphenate, 1% and 2% solutions, gives excellent control of sapstain after 10-15 second dips. At a 2% solution strength, 1 lb. is sufficient to treat 900 sq. feet of timber, or 5 lb. to treat one standard (as board feet.)7), 61). The use of arsenic or fluorine compounds is reported to encourage "blueing".114)

Fungal attack on sawn timber is minimised by proper storage during seasoning. The piles should be erected on solid foundations with a clearance of about 18" between the bottom boards and the ground. The growth of grass etc. below the piles should be prevented, and some means of protection against rain provided.14) Scrap wood, sawdust etc. should not be allowed to accumulate.

Lyctus (Powder post beetle) infestation can be avoided by dipping in, or spraying with water emulsions containing at least 2% DDT or 0.5% gamma-BHC.10),25)44) Treatment with 1% dieldrin is reported to be effective for at least 9½ months. When this beetle is already established it can be killed off by kiln sterilisation of the wood.16) In New South Wales 1-2% chlordane or 0.5-1% dieldrin is recommended for use against the Furniture beetle, Anobium punctatum.18) Some plywood being produced in New Zealand incorporates 0.3% dieldrin in the glue for protection against this insect.

In the near future Boocock45) is publishing a review on the insect pests of tropical timbers with particular reference to felled timber and lumber protection.

Log rafts can be protected against Terodo and Bankia attack by treating them with sodium arsenite.116)

IV. Protection Against Termites67),73),74),120),127),129)

Though termites are generally regarded as pests of tropical areas, their range now extends as far north as southern Canada, while in Europe damage has been reported from Paris, Hamburg and a number of other places.74) Occasionally of importance in agricultural crops, termites are best known for their destruction of structural timber, railway sleepers, posts, and other wooden objects.

Protection of timber against termites can be affected in two ways, by preventing the insects getting access to the wood, or by treating it with a preservative having repellant or toxic properties. A combination of both methods is frequently desirable.

Control by nest destruction is not satisfactory as many species responsible for damage do not produce conspicuous nests. The practice of digging out and killing the queen to destroy a colony, as carried out by some "termite-control" practitioners, is based on a profound ignorance of the insect's biology, and is quite valueless.

The choice of a preservative for protection against termite will depend on the required durability, the conditions to which the timber will be exposed and the use to which it is to be put, the insect, and timber species, and the cost of using the preservative.

Where timber is to be used in a permanent structure - buildings, bridges, etc. - preliminary soil poisoning of the site is desirable. Arsenic has proved to have a long lasting effect, and is popular in many places. A number of the modern synthetic chemicals, pentachlrophenol, sodium pentachlorophenate, dieldrin, gamma-BHC, DDT, heptachlor and others, show great promise in this field, but tests have not yet lasted long enough to prove that they have the required durability.77) Creosote and creosote based preparstions, when properly applied, have been shown to give protection to wood for periods of up to 40 years.9)

Their use, however, is limited by the nature of the surface left on the wood. Arsenic, incorporated in water borne preservatives, has been effective for periods of 30 years. Again the new synthetics may well prove equally enduring. The design of a building materially effects its susceptibility to termite attack, and a great deal of research has been undertaken in this respect.73)

Many preservatives may be used on non-structural timber, railway sleepers, posts, poles, etc., where untreated wood is rapidly destroyed. The choice ultimately depends on local conditions and economics. Results of tests that have been carried out show conflicting results, due doubtless to different methods of application, conditions of use, and intensity of attack. Compounds which have given protection for appreciable periods include gamma-BHC, DDT, dieldrin, isodrin, P.C.P. and various of its salts, chloronaphthalenes, creosote, arsenic, and others.

V. Preservation of Timber21),27),82),101),130),134)

Durability of Timber2),3),52),109)

The durability of timber varies from species to species, within the same species and to different organisms. It is governed by such factors as internal structure, density, hardness, moisture content, and whether resin, oil or other constituents are present. Recent tests on tropical American woods, for example, have shown that woods with high silica contents exert an inhibitory effect on molluscan and crustacean organisms.121) The longitudinal permeability to air, of about a hundred hardwoods and softwoods has been measured.24) Hardwoods, it is stated, show a remarkably large permeability range; the value for each species is primarily a function of the diameter and number of the wood pores, but in the most impermeable, blockage of these pores by cell deposits is considered a more important factor. In general, the most impermeable woods are also the most durable, and vice versa, so that it seems probable that both properties may be directly related to the blockage of pores, which could form both a physical and a chemical deterrent to fungal attack. The softwoods have a much smaller range of permeability and the relation of durability to impermeability does not hold.

Durability is invariably improved by seasoning and substantially through chemical treatment. Many timbers of relatively low natural durability can be employed, after impregnation with suitable chemicals, in situations conducive to pest attack. Preservative treatment may also usefully be applied to "forced" wood, i.e. wood grown in artificial plantations to reach marketable size in 90 to 120 years. Such wood is characterised by a higher sapwood content and wide growth rings.

Sapwood forms the "live" part of the tree beneath the bark. Heartwood constitutes the inactive, central core. Sapwood is particularly more susceptible to insect attack but, being more porous, can be more readily treated. The minimum requirement for long term protection is that the preservative should completely penetrate the sapwood. Heartwood is generally much more resistant but may yield to incision and pressure techniques.

Origins of Wood Preservation

Preserving wood is an ancient craft. The early Greeks and Romans realised that timber kept under water was less subject to decay46) and the Chinese, before 100 B.C. treated building timbers by immersion in sea water or salt lakes.71) Application of cedar and larch oils,46) and surface charring76), are measures of great antiquity. The use of mercuric chloride, copper sulphate and creosote dates from the 18th century.82) At first treatment was by brushing or steeping; later, pressure techniques were devised including those of Bethell (1838), Boulton (1881), Hot and Cold Tank (1867), Rueping (1902) and Lowry (1906).59)

With modern preservatives and improvements in technique the life of timber can be increased with certainty. Creosote oils and water-borne mixtures of inorganic salts are much used in pressure treatment. Another type of preservative, consisting of an organic compound, as pentachlorophenol, dissolved in light mineral oil, is frequently employed for treating the face of timber, in situ.

Pressure Applications27)

For lasting effect under conditions of severe exposure, e.g. timbers in ground contact including railway sleepers, telecommunication poles, mine timbers or those in contact with water, preservative is applied under pressure, normally to debarked, seasoned timber (moisture 25-30%).

The effectiveness of pressure treatment is influenced by the toxicity of the preservative, its degree of penetration, and the size of the timber. Penetration is governed by the method and conditions of application, the physical properties of the preservative and the permeability of the timber. Tables of permeabilities for home grown and Empire timbers, based on a standard comparison test, have been compiled by the Forest Products Research Laboratory. (see Appendix III).

In practice the preservative is forced into the wood cells under pressures of the order of 100-200 lbs/sq.inch, although in Australia pressures of 1,000 lbs/sq.inch have been reported.56) To facilitate penetration, preservative is normally heated to about 160°F. In some treatments a partial vacuum is created during the process. Plant104) consists of a large, pressurised, steel treating cylinder together with storage tanks, mixing tanks, vacuum and pressure pumps, a method of heating and instrumentation.

Principal techniques (Table II) are the Full Cell method, which, originating in the Bethell process, leaves the cells of the wood full of preservative, and the Empty Cell method, such as the Rueping and Lowry processes, in which some of the preservative is withdrawn leaving the cell cavities empty and the cell walls coated with preservative. A sap displacement process (Boucherie) is applicable to freshly felled timbers. It is at present employed in Finland with waterborne preservative.

Two methods have been devised to impregnate green timber in circumstances which prevent proper seasoning. These involve boiling under vacuum (Boulton) or steaming and vacuum.

Other Methods of Application50)

Non-pressure methods depend upon the physical sorption process, in which permeability and duration of contact are major factors. Techniques vary from steeping to dipping, brushing and spraying. In steepings waterborne salts are suitable for both green and seasoned woods, though green woods absorb by salt diffusion only. Two stage double-diffusion techniques are reported34) which consist of soaking green wood for at least two days in consecutive salt solutions of strength not less than 5% w/v. The salts diffuse into the wood where they react to form a toxic precipitate. Good results have been obtained using copper sulphate and sodium chromate.

Oil borne preservatives are applicable only to seasoned timbers. Fence rails, gates and duck boards are examples of items conveniently treated by steeping. Effectiveness can be appreciably increased by alternately heating and cooling the preservative in contact with the timber. (Hot and Cold Open Tank Treatment).47) Part of the cell space originally occupied by air is replaced with the preservative fluid. A large temperature difference is desirable but the upper temperature should be compatible with the safe working of the process and the chemical stability of the preservative.

TABLE II

Pressure Impregnation Methods

Process	Description	Notes
For Seasoned Timbers		
FULL CELL (Bethell)	The timber is placed under vacuum (28" Hg) for 15 mins. to several hours according to size and permeability. Preservative (140°–180°F) is then added followed by application of pressure (100-200 lbs/sq.in.) for 1-5 hours normally, sometimes several days.	Cell spaces remain full of preservative. Method normally used for treating railway sleepers, marine timbers and cooling towers.
FULL CELL Modified	In use in Canada and U.S.A. for more resistant timbers (British Columbian, Oregon Pine, Western Hemlock). During treatment pressure is released to atmospheric once or twice to facilitate up-take of preservative.	
EMPTY CELL (Rueping)	Air surrounding the charge is compressed to 30-50 lbs/sq.inch for about ½ hr. following which preservative is injected at considerably higher pressure (exceeding 100 lbs/sq.inch) maintained for at least 1 hr. To complete treatment a partial vacuum is created.	Partial vacuum at close of treatment causes air, injected at beginning, to expand and thus to force out free preservative. A film is left on the cell walls. Advantages of timber so treated are: 1). less likely to exude preservative in warm weather 2). cleaner to handle In use by G.P.O.
EMPTY CELL (Lowry)	Initial compression phase of Rueping is omitted. Other stages as described above.	
For Unseasoned Timber		
Boucherie	Method for displacing sap in freshly felled or water-submerged unpeeled timber with a waterborne preservative. Originally applied to standing trees. Preservative passes from an elevated tank (30 ft.) through rubber tubes connected to the pole ends.	A modified method for treating green bamboo has been described.96)

Cold dips and brush or spray treatments rely upon the formation of a shallow protective barrier of preservative. With such there is risk of untreated wood readily becoming exposed through checks, abrasions or on subsequent working of the timber.

Preservatives in Use42), 115)

Wood preservatives are conveniently grouped under water solution (waterborne), organic solvent or tar oil types (B.S. 1282: 1945).1)

The first class comprise the inorganic salts and their mixtures, and others include the organic compounds. General requirements are high pest toxicity at low concentrations, low mammalian toxicity, good penetrability, permanance and non-deleterious action. Colour, odour and phytotoxicity are of consequence in certain applications.

Tar Oil Types

These are composed of coal (or wood) tar distillates and are of general applicability to external woodwork. Products have a characteristic odour which is capable of tainting food or causing plant injury. They are relatively cheap, plentiful, durable and resistant to leaching. Most widely used are the coal tar creosotes.

Coal Tar Creosotes48),83),91)

These are suitable for pressure and surface application. Their quality as wood preservatives is specified in B.S. 144 and their use in pressure treatment in B.S.913 and B.S.1990. Competently applied, creosote will protect timber against fungi, insect and marine borer attack for upwards of 15-20 years. The composition of creosote varies according to type (high, low, medium residue; vertical retort or coke oven tar) but consists essentially of blended tar distillate oils of boiling range (200-400°C) including naphthalene oil, wash oil, light anthracene and heavy oil fractions. The toxicity of creosote is attributed to the variety of, and possible synergism between, the many compounds present, nearly two hundred of which have been identified. Creosote does not corrode metals and minimises tendency of wood to split. Its dark colour, strong odour and propensity to "bleed" limit its use to circumstances where appearance is not important. Creosote bleeding may be prevented by applying a polyisocyanate preferably 2,6-tolylene-di-isocyanate at 20-40 p.s.i. for 10-30 minutes followed by an alkali wash.125)

Other Tar Oil Preservatives

Coal tar has much less effect on destructive pests and is more viscous and darker in colour than creosote. It does not easily penetrate wood and is of doubtful value when used alone. Railway sleepers or cross-ties are sometimes treated with tar mixed with creosote. Mixtures of creosote and coal-tar appear to offer better protection against Limnoria than do straight creosotes particularly of the vertical retort tar type.100)

Wood tar creosotes, which are not extensively used, are corrosive to metals because of high tar acid content. Distillates of wood tar are present in some proprietary materials.

Water-gas tar is formed during the decomposition of petroleum oils. This and its creosote are sometimes used for diluting coal tar creosote.

A number of proprietary brands of tar oil preservative are available, from which the coloured and odorous constituents have been removed.

Waterborne Salts

It has been well known for many years that solutions of certain inorganic salts including zinc chloride, mercuric chloride, sodium fluoride, copper sulphate, borax, magnesium silico-fluoride and alkali arsenites and arsenates possess wood preserving properties. Sodium fluoride (2-3% aq. solution) gives effective control of wood destroying insects and fungi and has often been used for treating indoor timbers for dry rot. It is more commonly used now in mixtures containing dinitrophenol, alkali dichromate and arsenates ("Wolman Salts"). Mercuric chloride is extremely poisonous; it is little used now except in parts of Central Europe where a modification of the Kyanising process (1832) is still practised. Magnesium silicofluoride and zinc meta arsenite have fallen out of favour. Arsenic compounds are normally incorporated when termite control is required. Borax is much used on timber likely to come into contact with foodstuffs and boric acid (2-5%) borax mixture has been used against Lyctus in Australia. The impermanence through leaching of copper sulphate and zinc chloride especially in outdoor applications, had led to the development of safe, durable preservatives capable of being injected under pressure in aqueous solution. These consist of salt mixtures which become highly fixed (over 97% fast) in the wood after treatment through oxidation-reduction mechanisms and changes in the pH. Acidulated copper/chrome salt mixtures are most widely used also fluoro/chrome mixtures and chromated zinc chloride. Arsenical compounds are again added for controlling termites. Smith et al. have described a pressure-vacuum treatment using dilute copper formate. An uptake equivalent to 0.8% copper based on weight of treated wood gave prolonged resistance to decay and marine boring organisms.110)

Waterborne preservatives are generally without fire hazard and odour; they are easier and cheaper to transport than creosotes and the wood can normally be painted over when dry. Redrying is usual after application since their use generally causes swelling of the wood. They are usually applied below 150°F since some metallic salt solutions will decompose above this temperature.

Organic Solvent Types11),75)

These consist of organic compounds (e.g. chlorinated phenols, metallic naphthenates, chlorinates naphthalenes) in a relatively volatile organic solvent generally a petroleum or coal-tar distillate (distillation range 140°C-270°C) such as white spirit, kerosene, light petroleum distillates or high flash naphtha. This class of preservation is, in the U.K., more widely applied in surface treatments (dipping, spraying and brushing) in circumstances that do not require the deeper penetration afforded in pressure treatments.

Certain oil solvent type formulations are suitable for use in the Hot and Cold Tank Process which in the absence of pressure plant facilities offers a convenient method of obtaining a substantial degree of protection. Such treatment is applied to railway sleepers in Indonesia and other remote territories. Ease of penetration, chemical stability and resistance to leaching are useful properties of this type. They are non-creeping and non-staining, the wood can be painted when dry, and they are non-corrosive to metals. There is however, a fire hazard connected with their use and possibility of odour becoming absorbed by foodstuffs.

Pentachlorophenol19) is recommended for use in surface and pressure treatments at 5-7½% w/v. Recommendations are normally based on a solution in gas oil (5% w/v), or more volatile oils. In the U.S.A. it is employed in pressure treatments in medium and heavy petroleum oils 5-7½ w/v.28) Volatile solvents such as white spirit or naphtha are now being employed in a solvent recovery process. If the heavier solvents are used the finish is likely to be more stained and oily.

PCP is a crystalline solid (m.p. about 175°C) chemically stable with low volatility and virtual insolubility in water. It is effective against wood destroying fungi and termites. Since it is highly toxic to plant life and, at some levels, towards humans it is not applied to horticultural timbers or those to be used near foodstuffs.

The metallic naphthenates[51] (especially copper naphthenate) are oil based preservatives. Naphthenic acids are extracted from crude petroleums or petroleum distillates. Copper naphthenate, in hydrocarbon solvents, (containing at least 20% w/v equivalent to 2% w/v copper) is employed in the U.K. for surface treatment. Copper naphthenate, insoluble in water and involatile, does not impair the paintability of the wood and is electrically non-conducting. It is toxic to a wide variety of fungi and shows some effect against termite and marine borers. In a suitable solvent it may be applied hot under pressure. The naphthenates are non-toxic to plant life and can safely be used on horticultural timbers.

The chlorinated naphthalenes appear only to have been applied on a restricted scale in the U.K. but widely in Germany. They are stated to act fungicidally and insecticidally both as a respiratory and contact poison. The mono- and di-chlorinated naphthalenes are liquids and of relatively low mammalian toxicity. The higher members are waxy solids and, though of lower volatility and greater stability, are more toxic to humans and animals.

Copper 3 phenyl salicylate[90] (5% w/v solution) has found service for the treatment of wood likely to come into contact with plants, food or human skin (e.g. seed boxes, food crates and tool handles). The solid is tan, crystalline, odourless and non-volatile. It is essentially insoluble in water but soluble to at least 5% w/v in many organic solvents including xylene, trichlorethylene and linseed oil. It appears to be more effective when used in conjunction with a water-repellent.

Mixed Preservatives

The metallic pentachlorophenates (e.g. zinc and copper salts) are formed in mixtures of pentachlorophenol and metallic naphthenates. Less volatile than PCP they are virtually insoluble in water and possess a higher toxicity to fungi and insects, particularly termites. The merits of oil based preservative mixtures, which have been in general use in the U.S.A. for several years, are becoming better appreciated. Combinations appear to exert a synergistic effect or to possess a wider range of activity. Most commonly employed are creosote/PCP and creosote/copper naphthenate mixtures. It has been customary in the States to add petroleum oil as an extender.

Treatment of Timber in Situ[102)]

To counteract outbreaks of decay in inadequately protected outdoor timbers a piston-operated device has been designed to inject preservative fluid through a perforated blade forced into the bad wood. Further decay is inhibited by subsequent diffusion of preservative. In some cases holes or incisions are made which are then filled with paste and stoppered. Another technique consists of applying a water-proof bandage, incorporating preservative to the diseased portion of the wood.

The control of indoor timbers infested with fungal rots and boring insects may be accomplished in straightforward cases (e.g. furniture attacked by 'woodworm') by a brush, spray or "squirter" application of liquid. In others, e.g. dry rot in built-in bonding timbers, or old timbers infested with death-watch beetle, considerable skill and experience are required, involving exact knowledge of the pest, the most suitable formulations to use and the effective means of application.[102)]

Organic solvent type preservatives are normally used for in situ work because of their penetrating, non-leaching and stable properties. Solvents of the higher petroleum oil type which are odourless, non-staining and non-injurious to property, are generally preferred. Since the solvents may form explosive mixtures with air, this risk, together with that from the possible toxic properties of the vapour, must be avoided during treatment by securing adequate ventilation. Preservatives added include metallic naphthanates, pentachlorophenol and its sodium salt, sodium ortho phenyl phenol and chloronaphthalenes; gamma-BHC, DDT, dieldrin and other insecticides are frequently used to increase the insecticidal effectiveness. Water repellent compounds[126)] (e.g. silicones, synthetic resins or waxes) are sometimes incorporated to oppose changes in the moisture content of treated timber and thus to minimise tendency of the wood to swell. Items treated with water repellent can remain out-of-doors for several weeks without detriment to the timber. Penetrants (e.g. trixylyl-phosphate) may be added.

Table III over indicates some methods of treating infested timber. The application of two or three coats with a drying out period between each is sometimes recommended.

TABLE III

Insect and Fungal Pests

Pest5),27),63),78),111)	Notes on Pest	Control Measures
Insect Pests		
Powder Post beetles Lyctus spp.	Life cycle of 1 to 2 years. World wide distribution. Beetle is reddish brown about 6 mm long. The sapwood of certain hardwoods is attacked. Eggs are laid within the wood vessels at a depth of several mm. Bore dust is soft and silky.	2% DDT spray for use in temperature zones or 0.5% gamma-BHC in the tropics, applied to surface of timber. For treatment of stacked timber 10 galls 2% DDT emulsion per 1,200 cu.ft. is recommended.
Death Watch Beetle Xestobium rufovillosum	Life cycle from 3 to 10 years. Beetle is dark brown, mottled, about 7 mm long. Mainly attacks hardwoods already supporting fungal rot. Old structural timbers (e.g. in churches, museums) are particularly susceptible.	Ventilate to obtain drier conditions. Pare away badly tunnelled wood and scrape surface clean. Remove debris. Treat chemically with 4% DDT in kerosene, or 5% PCP in oil base; fumigation with HCN or methyl bromide is indicated for heavy infestations.
House Longhorn Beetle Hyletrupes bajulus112)	Life cycle upwards of 12 years. Beetle is black with covering of greyish hairs. Attacks sapwood of seasoned hard and soft woods, especially roofing and structural timbers, Larval galleries are tightly packed with bore dust.	Clean surface and remove debris. Treat chemically with 5% DDT in deodorised kerosene, or 5% PCP, or 2% chlordane or 0.5% lindane, in oil base. Heavy infestations can be treated by fumigation with HCN or methyl bromide.
Common Furniture Beetle Anobium punctatum	Life cycle of 2 to 3 years. Beetle is chocolate brown about 3 mm long. Eggs are laid in cracks or crevices of furniture, etc. Mostly sapwood of seasoned wood is attacked but can spread to heartwood. Bore dust is gritty. It is estimated that 4/5ths of woodworm damage is by this insect.	Clean surface and treat chemically with 1-2% chlordane or 0.5-1% dieldrin or 10% dichloro ethyl ether18) or 5% PCP, or copper naphthenate111), in oil base.

Pest5),27),63),78),111)	Notes on Pest	Control Measures
Fungal Pests		
Dry Rot *Merulius lacrymans*	Indoor fungi requiring damp conditions but able to spread to dry wood. Normally attacks softwoods but can spread to hardwoods, also to brickwork and plaster.	Remove infected timber, dirt, debris, etc. Heat sterilise affected brickwork and plasterwork. Apply fungicide in aqueous solution to surface whilst hot. Replace with sound timber and treat woodwork with oil based fungicides. Eliminate root of trouble. Ensure good ventilation and keep woodwork dry.
Wet Rot Cellar Fungus *Coniophora cerebella*	On damp wood in old buildings and outdoor timber. Both hard and soft woods are attacked. This fungus requires excessive moisture conditions.	Follow treatment above. Zinc salt in preservative required to combat *Poria* and *Coniophora*.
Mine Fungus *Poria vaillantii*	Moisture requirements are greater than for Merulius but it has only a limited power to spread beyond damp area.	Follow general instructions given above.
Horticultural Fungus *Poria xantha*	Found in still, humid warm atmospheres (hot houses and greenhouses)	Follow general instructions given above.
Lentinus lepideus	Attacks unprotected softwood timber out-of-doors	Follow general instructions given above.
Soft Rot *Microfungi complex*	Encountered under severe conditions of humidity and temperature (e.g. cooling towers.)	Timbers are impregnated with non-leaching copper salts.

APPENDIX I

BRITISH EAST AFRICAN SPECIES OF EXPORTED TIMBERS

Species	Principal Source	Some European Uses	Notes on Preservative Treatment, etc.
Hardwoods			
Mvule (Iroko) *Chlorophora excelsa.*	Widely distributed from Sierra Leone to Tanganyika territory.	Joinery, cabinet work	Substitute for teak. Can be worked with moderate ease. Practically untreatable with preservative even under high pressure
East African Blackwood *Dalbergia melanoxylon*	East African territories.	Ornamental turnery	Similar properties to ebony. Standing tree subject to borer attack which can tunnel into heartwood
Muninga *Pterocarpus angolensis*	East African territories.	Superior joinery, flooring, furniture.	Seasons and works well. Sapwood subject to borer attack.
Camphorwood *Ocotea usambarensis*	Kenya colony	Cabinet work, superior joinery, etc.	Not very difficult to work. Seasons without much difficulty, Impermeable to preservatives.
Softwoods			
Cedar *Juniperus procera*	Kenya, Tanganyika and Uganda	Cabinet work, pencils.	Easy to work. Requires careful seasoning. Resistant to termites Extremely resistant to preservative.
Podocarpus spp. (Podo)	Kenya, Tanganyika and Uganda.	High class joinery timber, interior fittings.	Seasons well and works easily. Permeable to preservative by open tank or pressure treatment.

APPENDIX II

PROPERTIES OF PRINCIPAL SPECIES OF TROPICAL TIMBERS (HARDWOODS) EXPORTED FROM WEST AFRICA

Species	Principal Source	Indicated European Use	Properties
Okoumé Gaboon Mahogany Aucoumea klaineana	French West Africa	Plywood and laminwood	Difficult to work because of woolly nature. Extremely resistant to impregnation
Obeche African Whitewood Triplochiton scleroxylon	Nigeria, Ghana chiefly	Interior joinery	Difficult to work; requires careful seasoning. Wood from centre of tree appears to be resistant to impregnation with creosote. Outer wood is readily treated.
Limba White afara Terminalia superba	Tropical West Africa from Sierra Leone to Cameroons	Rotary cut veneer	Resistant to creosote by open tank process. Less resistant to penetration by aqueous solutions.
African Mahogany Khaya spp.	Coastal rain forests of West Africa	Panelling, furniture, interior fitting	Classed as untreatable.
Sapele Entandrophragma cylindricum	Widely distributed in West Africa	Furniture, panelling, interior fitting	Resistant to impregnation by open tank process
Abura Mitragyna ciliata	Nigeria	General utility timber	Moderately easy to treat by open tank process
Makoré Mimusops heckelii	Nigeria, Ivory Coast, Ghana, Liberia and Sierra Leone	Furniture, veneers, interior fittings	Very resistant to impregnation by open tank method. Requires care in seasoning.
Utile Entandrophragma utile	Ghana, Liberia	Furniture, veneers, interior fittings	Requires careful seasoning; good working qualities. Resistant to impregnation by open tank process.
Agba Gossweilerodendron balsamiferum	Southern Nigeria	Light weight general utility hardwood	Very resistant to impregnation by open tank process.

APPENDIX III – CLASSIFICATION OF TIMBERS IN ORDER OF PERMEABILITY(2,3,27)

Impermeable 1	Extremely Resistant 2	Very resistant 3	Resistant 4	Moderately Resistant 5	Permeable 6	Vessel porous 7
Brush Box Camphor, East African Guarea Guarea, scented Jarrah^{7} Karri Tallowwood Turpentine	Cedar, Africa pencil Gaboon Greenheart Idigbo Iroko Keruing^{1,7} Mahogany, African Mahogany, Central American Mahogany, Honduras Nargusta Oak (Home-grown) Padauk, Burma Pyinkado Teak	Aspen, Canadian Cedar, Western Red Chestnut, sweet Douglas Fir^{5} Gum, American Red Larch Larch, Japanese Oak, American White Oak, Tasmanian Obeche^{4} Poplar^{7} Spruce, Canadian Walnut Willow	Balsa Birch, Canadian Yellow^{5} Elm, rock Keruing^{2,7} Maple, rock^{5} Muninga Obeche^{3} Spruce (Home-grown) Spruce, Sitka Whitewood, European	Ash Birch, Canadian Yellow^{4} Celtis Cottonwood Douglas Fir^{3} Fir, Silver Hemlock, Western Maple, rock^{4} Opepe Padauk, Andaman Pine, Corsican Pine, Honduras Pitch Pine, Jack Pine, Pitch Pine, Red Pine, Scots (Home-grown) Pine, Western White Pine, Yellow Redwood, European	Alder Basswood Beech Birch Chestnut, Horse Coachwood Hornbeam Lime Oak, American Red Odoko Podo Sycamore Tupelo gum	Balsa^{4} Bombway, White Celtis^{5} Eng. Gurjun Jarrah^{1} Keruing^{2,4} Poplar^{3}

Where a timber is classified in more than one group the index numbers show the alternative groups into which it may fall through variation in permeability.

APPENDIX IV TYPICAL PRESERVATION TREATMENTS

Application	Preferred Timbers	Preservative Treatment	Ref.
Transmission poles	Scots pine (European Redwood), Douglas fir, Norway spruce and larch	Pressure treatment using modified Rueping as specified in B.S. 913 and B.S.1990. Specification requires 14 lbs gross or 17 lbs minimum nett retention coal tar creosote. Waterborne preservative (copper sulphate/dichromate and fluorchrome) reported to be under test.	40 88
Railway sleepers	Baltic Redwood, Douglas fir, Hemlock and various European pines	Pressure treatment using Reuping process to specification B.S.144 (creosote); copper/chrome and fluor/chrome mixtures under test	20 103
Mining timber	European larch, Scots pine, Norway spruce and certain other conifers	Full cell (Bethell) treatment with creosote or waterborne preservatives can extend life from a few months to ten years	79
Marine timber	Pitch pine, Greenheart Elm and Douglas fir chiefly. Oak, jarrah larch, beech and others noted	Both full and empty cell treatments are employed. Creosote used to good effect. Waterborne preservatives under test.	128
Cross arms for transmission poles	About 20 timbers specified including Douglas fir and oak.	Dip treatment in open bath	
Interior building timbers (not enclosed or in ground contact)	Various	Treatment by steeping, brush spray or dipping is satisfactory (B.S.1282: 1945)	1

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